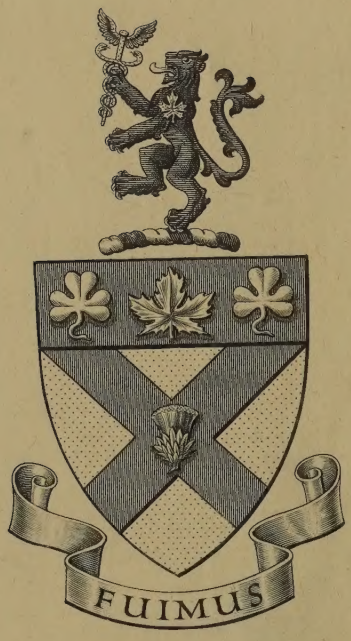
SURGICAL PAPERS

BY

WILLIAM STEWART HALSTED



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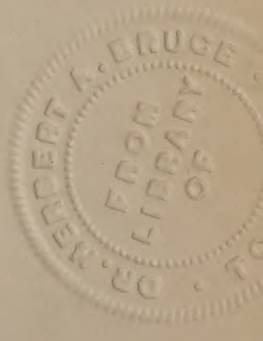

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WILLIAM STEWART HALSTED

1852–1922

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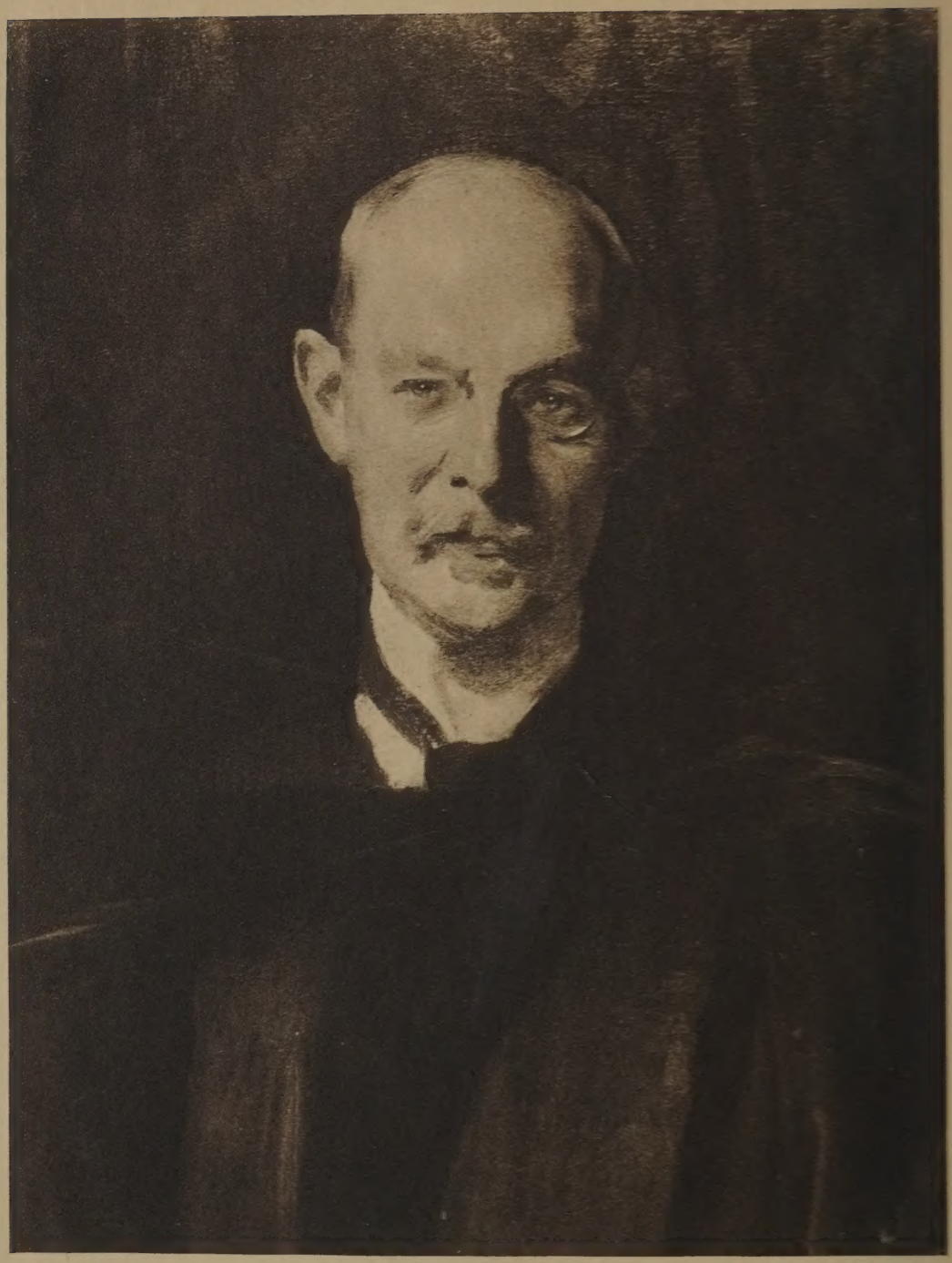

June, 1905

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From Sargent's "Four Doctors"

SURGICAL PAPERS

BY

WILLIAM STEWART HALSTED

IN TWO VOLUMES

VOLUME ONE

BALTIMORE
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IN HONOR OF

WILLIAM STEWART HALSTED

1852–1922

THIS COLLECTED EDITION

OF HIS PAPERS AND ADDRESSES IS PUBLISHED

AS A MEMORIAL OF LOVE, ESTEEM, AND INDEBTEDNESS

BY HIS ASSOCIATES AND PUPILS

EDITOR'S NOTE

The late Dr. William Stewart Halsted, who was Professor of Surgery in The Johns Hopkins University and Surgeon-in-Chief of The Johns Hopkins Hospital from the date of its opening in 1889 until his death on September 7, 1922, would have been seventy years old on the twenty-third of that month. A committee of his colleagues had decided that the most suitable commemoration of this anniversary would be the publication of his collected papers which, as is known, was the form of recognition most acceptable to Dr. Halsted himself. And now these volumes are held to be a fitting memorial of Dr. Halsted's life and work.

When one considers the number, originality, and importance of Dr. Halsted's contributions to surgery during the last forty years, which have placed him in the front rank of modern surgeons, and their scattered and often not readily accessible form in journals and reports, it is realized that this publication not only constitutes a worthy tribute to his memory but also renders a much needed service in making available these significant contributions.

The volumes reveal the important part played by their author in the advance of modern surgery during a period of great progress which was stimulated by the discovery of anaesthesia and infectious microorganisms. Dr. Halsted's distinct published contributions include: blood refusion by centripetal arterial transfusion in carbonic oxide poisoning; the effect of adduction and abduction on the length of the limb in fractures of the femur; the employment of fine silk in preference to catgut and the advantages of transfixing tissues and vessels in controlling haemorrhage; the introduction of rubber gloves, gutta percha tissue, silver foil, the mattress intestinal suture, and the subcuticular stitch; special emphasis of the blood clot in the management of dead spaces in the treatment of wounds which has led to its more widespread use and appreciation; the open-air treatment of sur-

gical tuberculosis; the introduction of conduction (so-called block) anaesthesia; circular and lateral intestinal anastomoses; the bulkhead method of end-to-end intestinal suture; the blind-end circular suture of the large intestine, the closed ends abutted and the double diaphragm punctured with a knife passed per rectum; original operations for the radical cure of inguinal hernia, cancer of the breast, goitre, aseptic intestinal anastomosis; the partial, progressive, and complete occlusion of the aorta and other large arteries by metal bands in the cure of aneurism; the relation of dilation of the subclavian artery to cervical rib; the successful ligation of the left subclavian in its first portion for the cure of a huge subclavian aneurism; the transplantation of the parathyroids; the retrojection of bile into the pancreas as a cause of acute haemorrhagic pancreatitis; the omission of drainage in common-duct surgery; a method of closure of the cystic duct after excision of the gall-bladder; Thiersch skin-grafts after radical breast amputations; and the replantation of entire limbs without vessel suture.

Starting with the author's first published contribution "Blood refusion in the treatment of carbonic oxide poisoning" the papers on similar subjects, although scattered over a number of years, have been placed together chronologically in groups. An attempt has been made to unify, in a form preferred by Dr. Halsted, the varying orthography of the different books and journals.

In behalf of the Committee the editor wishes to thank editors and publishers of books and periodicals for their hearty consent to the use of articles and illustrations appearing in these volumes. A great debt of appreciation is due to Dr. Rudolph Matas for permission to use his memorial tribute to Dr. Halsted as the introduction to the volumes. To The John Crerar Library for the free use of its books, to Mr. D. Chong Chun of Hawaii for his assistance in proof-reading and to the many associates and friends of Dr. Halsted who have given valuable help, the editor acknowledges his indebtedness.

WALTER C. BURKET, *Editor.*

JANUARY, 1928.

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W. S. Halsted

WILLIAM STEWART HALSTED
1852–1922

AN APPRECIATION *

When I accepted the gracious invitation of President Goodnow to join the friends of Professor Halsted in a public tribute to his memory, I did so gladly and gratefully. Indulging in no vain illusion that anything which I might say could add weight to such merits and virtues as have exalted his acknowledged rank, nor that, by any grace of speech, I might place further emphasis upon the eloquence of those far abler to express the sentiments of affection and admiration which Dr. Halsted inspired, I was conscious, nevertheless, that, although one of the least worthy among his friends and admirers, none other would come to this gathering whose heart overflowed with greater gratitude and appreciation.

Few have been permitted to enjoy such immeasurable good as came to me through him. Not only profiting by his sympathy, counsel and experience in a way far exceeding the benefits that have accrued to many of his nearer colleagues and associates—benefits that have contributed in no small measure to my professional enlightenment and improvement—I also owe him a debt which is far more direct and personal, a debt that cannot be estimated nor expressed in mere words. In his lifetime, he had rendered me a service in which his surgical skill and kindness had united to relieve me of a heavy burden—thereby making my travel through life much lighter, and introducing contentment and confidence where previously there had been only uncertainty, danger and doubt. It is, therefore, as a debtor, in more than one sense, that I am here, seeking to repay that which I can never hope to return, even in small installments.

Though not of Dr. Halsted's official family, and with no claim to recognition as one of his pupils and associates, I feel that, through the ties of strong affection that bound me to him, I am entitled to wear the badge of mourning which, if not outwardly displayed, is well wrapped around my heart.

You will pardon this allusion to my personal relations with Dr. Halsted. It has no other purpose than to disclaim any pretense to exploit my friend-

* An address by Dr. Rudolph Matas, Professor of Surgery, Tulane University, New Orleans, La., delivered on the occasion of the memorial meeting for Dr. William Stewart Halsted, held at Homewood, December 16, 1923.

Johns Hopkins Hosp. Bull., Balt., 1925, XXXVI, 2.

ship for him or the warm feeling that I have every reason to believe, he entertained for me; nor any motives that might redound to my own advantage; nor that I might assume the privilege of acting as his biographer on this occasion. Even though this function were becoming in me, this is not the time nor place in which to exercise it. That must be the sacred part of those who dwelt in close and intimate association with Dr. Halsted; who living with him in daily communion, participating in the routine activities of his life, are privileged to write a biography that will do justice to his labors and to his personality. This task has been in some measure accomplished in the appreciative notices which have recently appeared over the signatures of two of his most eminent associates and co-workers, Drs. Cushing and Finney. These two admirable sketches suffice to acquaint those who did not know Dr. Halsted personally with the outstanding facts of his life, his antecedents and personal characteristics; but to an audience like this, composed largely, if not wholly, of Dr. Halsted's friends, assembled within the walls of the institution which still resounds with the familiar echoes of his voice and retains much of the warmth of his loved presence—a rehearsal of such well known facts would be like bringing coals to Newcastle—a superfluous undertaking. I shall, therefore, dispense with purely biographic details which in the main I should have to borrow from others more competent to speak, and I will confine myself to a simple appreciation of his life from the viewpoint of one, who, looking at him from a distance, kept in close touch with his work and felt a deep interest in his professional achievements; who felt for him that warm sympathy which is engendered by a veneration akin to that of the pupil for a beloved master; who felt for him all the loyalty and sincerity of a grateful friendship, and all the congeniality which is born of a communion of ideas and mutual interests in a common field of endeavor.

What I shall have to say, at this moment, is largely prompted by the very exuberance of my affection, by the very joy of speaking of him, and out of the fullness of my admiration.

We know enough to assert his greatness without fear of exaggeration, but it is our successors, and the generations that will follow them, who, in the light of history, will assign to him its full and just measure.

*
* *

My interest in Professor Halsted began early in my professional career, when the distinctive qualities of his work had begun to attract attention,—foreshadowing his future eminence as one of the leading lights of surgery in this country. It was late in the eighties, when all eyes were turned towards

Baltimore, where the directing genius of Dr. John Shaw Billings had planned and laid the foundation for a medical school destined to revolutionize all previous concepts and standards of hospital organizations in America. As Director of the Surgeon General's Library in Washington, Dr. Billings' kindness and encouragement to the young men who frequented the Library is gratefully remembered by all who, like myself, were the recipients of his favor while he was the inspiring and generous custodian of that priceless repository of medical lore. It was through Dr. Billings that it was my good fortune to attend the opening exercises which inaugurated The Johns Hopkins Hospital in 1889, and it was from that eventful year that, chiefly through my devotion to Dr. Billings and my interest in the success of his enterprises, there developed a sympathy and affection for this institution which has grown stronger ever since.

I cannot refer to those early days without rubbing my eyes to visualize more clearly the great length of the path over which Medicine has traveled in that short span of scarcely four decades which have elapsed since the vigorous seed planted by the generous Hopkins has grown into the stately tree that is giving us shelter today. But, we cannot reflect upon the stupendous progress accomplished during this period in the history of American medical institutions, without evoking the image of that group of supermen—the great quadrumvirate, Welch, Osler, Halsted, Kelly, and their associates—who, by virtue of their example and achievements in this institution have exercised the most profound and salutary influence in directing and stimulating the medical profession of this country to the attainment of its present high aims and ideals.

It was not until 1903, just twenty years ago, that I first came to know Dr. Halsted in the light of his personal attributes as a man. Up to that time, I had become familiar only with his scientific attitude of mind, and, like every other surgeon in the country who is interested in the progress of his profession, I had been impressed with the importance of his researches, the originality of his ideas, and the thoroughness of his practice. We had met casually at the meetings of the American Surgical Association. In 1897, he had made a fleeting visit to New Orleans, in attendance upon the meeting of our national organization, where, contrary to his custom, he had reluctantly given a remarkable demonstration of his operation for hernia, at our Charity Hospital; but his reserve and caution in making new acquaintances, his seeming formality, always well concealed by the most perfect urbanity, made him rather difficult of approach and kept at a distance men who, fully aware of his great worth and of the prestige of his well earned national reputation, were eager to meet him but made no advances, owing to the impression that Dr. Halsted would not be over-responsive to their attentions.

In 1898 and 1899, in consequence of my interest in regional and local anaesthesia, I came into a closer knowledge of the pioneer labors of Dr. Halsted, which gave him the rightful claim to the discovery of neuro-regional anaesthesia—the so-called " conduction anaesthesia " of the German writers—better known with us as " nerve blocking " which, thanks to his initiative and personal experiments upon himself, led to the extraordinary developments of this mode of abolishing pain that we have all witnessed with amazement in the last few years. Not only did he clearly and unequivocally demonstrate for the first time that the principle of nerve blocking could be utilized to obtain the anaesthesia of the peripheral nerves for surgical purposes—a discovery promptly utilized in dental and oral practice—but he went a step further and demonstrated that the blocking of the spinal cord with anaesthetic drugs could be made subservient to this general principle.

From his early experiments and researches, a general law was formulated, which could well be named after him, " Halsted's Law," namely, that the infiltration of a sectional area of sensory nerve trunk or path, with an analgesic substance, was equal to the anaesthesia of its peripheral distribution. This, in essence, is the very foundation of all the present and most useful methods of regional anaesthesia.

He also anticipated and even went a step further than Schleich, who is credited as the originator of the principle that plain isotonic saline solutions, when massively infiltrated into the tissues so as to produce a tense local dropsy, were capable of producing local anaesthesia, even for surgical purposes; thereby demonstrating that extremely dilute solutions of cocaine and other dangerous anaesthetic drugs could be used effectively in almost infinitesimal dilutions, thus relieving them of their toxic qualities.

It is interesting to relate, as told by Cushing, that fifteen years later when Cushing rediscovered the principle of nerve blocking and applied it successfully in operations on hernia, publishing his well known paper on the subject, he was utterly unaware that his chief had ever made studies on cocaine of any sort—so reticent was Dr. Halsted about this matter and so little did questions of priority interest him.[1]

A similar illustration of his indifference to mere claims of priority was repeated only a year ago, 1922, when, in the course of a discussion at the American Surgical Association of a paper by Dr. Edward Klopp, of Phila-

[1] It is only quite recently, on April 1, 1922, barely six months before Dr. Halsted's death, that the fundamental importance and significance of his great discoveries in local and regional analgesia were duly recognized by the American National Dental Association. After the painstaking investigation of a committee headed by the distinguished dentist, Dr. C. Edmund Kells, of New Orleans, this representative body

delphia, on "Refusion or Reinfusion of Blood in Haemorrhage" it came to light that Dr. Halsted had frequently practised the procedure thirty years previously and had saved a number of lives by its application while acting

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presented him with the beautifully designed gold medal and gave him full credit as the originator of the method of neuroregional anaesthesia which has proven of such incalculable service in oral and dental surgery.

The following extracts from a letter addressed by Dr. Halsted to the writer, on April 3, 1922, the day following the brilliant and enthusiastic ovation tendered him by the National and Maryland Dental Associations, are quoted to show how thoroughly human Dr. Halsted was and how sensitively he reacted to this spontaneous and most genuine, though belated, tribute to his great discovery.

He wrote: "The Celebration, as Dr. Kells will tell you, was a remarkable success. I am so thankful to have lived to take part in it. Not a wink of sleep did I get during the night of Saturday. I was too exhilarated for repose. Once before in my life, I was kept awake by great happiness; this was the night that I passed successfully the examination for Bellevue Hospital in 1876. Here it was in contemplation of the future, now in reflection upon the good fortune that led to our friendship. The reaction from this great joy seems to be setting in tonight and my happiness is tinged with regret for the lost opportunities, for the time wasted from loss of health, etc."

In his touching allusion to "our friendship" with special reference to this occasion he had in mind the fact that I had been instrumental, without his knowledge, in securing complete and indisputable evidence of his right to priority in the discovery of regional anaesthesia "nerve blocking"—as applied especially to dental and oral surgery, and had established his historic right to recognition by the Dental Associations in papers published long before I had known him personally.

While local and regional analgesia had been one of his great passions, Dr. Halsted did not overlook the progress of general anaesthesia. In this also he was in the van of progress; for on February 17, 1910, while participating in a discussion at the New York Academy of Medicine, on Meltzer and Auer's method of intratracheal ventilation in its application to intrathoracic operations for purposes of artificial respiration and anaesthesia, he referred to his own experiments, at Hopkins, with differential pressure in pulmonary and intrapleural operations on the lower animals, and incidentally gave an account of his experience with a mixture of nitrous oxid, carbon dioxide and oxygen, which he has been using very successfully for one year in his clinic. In closing his remarks he said that before he had used these gases, he had not realized how detrimental the use of ether was in comparison. (*Med. Record,* March 19, 1910, p. 511.) Here we see him as a pioneer in a new field, trying and investigating a combination of anaesthetic gases at a time when gas-oxygen sequence and gas-oxygen mixture for prolonged surgical operations was practically unknown, and ether was still the universal anaesthetic in surgery.

In connection with the Meltzer-Auer method of intratracheal ventilation for artificial respiration, the following passage from a personal letter addressed to me by Professor Halsted on July 10, 1921, is interesting: "I wish I could have heard your paper on pneumothorax. You will, I trust, favor me with a reprint. Meltzer and Auer anticipated me in the publication of the insufflation method. Gatch, my assistant, and I had been working for some time along the same lines, but not knowing of Meltzer's work, were too deliberate. Meltzer was such a true friend to me that I would not in any event, have tried to anticipate him."

as surgeon at the old Chambers Street Hospital in New York. Credit had been given Johann Thiess of Leipzig, as the originator of this method of reinfusion or autotransfusion. This surgeon had published his experience in 1914 when he had applied it for the relief of exsanguinated patients in ruptured extrauterine pregnancy; but Dr. Halsted had clearly antedated him by at least thirty-one years, as will be seen by anyone consulting the files of the *Annals of Surgery* (vol. ix, pp. 7-21, 1884) and the *Proceedings of the New York Surgical Society* of November 13, 1883 (*New York Medical Journal,* 1883, vol. xxxviii, pp. 625-629), in which are described his experiences and clinical applications of the principle of blood "refusion" (as he termed it) in the treatment of illuminating gas poisoning. After copious blood-letting, the blood of the patient was collected, defibrinated and thereby sufficiently aerated to deprive it of its toxic properties. It was then filtered and reinfused into the radial artery of the same patient, thus administering an arterial centripetal infusion. The results obtained by this procedure—suggested to Dr. Halsted by reading Hermann's Physiology and Hütter's advocacy of arterial transfusion in preference to the venous route—were remarkable. Patients, who were comatose, would, after bleeding, promptly become conscious and even quite rational, and upon the reinfusion of the defibrinated and detoxicated blood would recover still further. The technique of refusion in haemorrhage, as practised at the present time, is different in many respects, but remains essentially the same in principle as that first applied by Halsted, forty-three years ago. And, yet, as in the case of the discovery of neuroregional anaesthesia, it would have remained buried in oblivion, so far as Dr. Halsted himself was concerned.[2]

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* *

It was in the fall of 1903, a little over twenty years ago, fourteen years after I had known Professor Halsted as a great soulful surgeon, that I came to know him for the first time by personal contact and under circumstances which revealed the still greater qualities of his heart. As I was convalescing in his home, I learned to love the sound of his cautious footsteps as he approached my room late at night, to assure himself of my comfort and to

[2] Two remarkable incidents which occurred early in Dr. Halsted's career are recalled by the reference to his original method of blood "refusion." The first is the saving of his sister's life when exsanguinated, seemingly moribund from the effects of post-partum haemorrhage. He arrived at the critical moment, arrested the haemorrhage which had resisted the efforts of the attending obstetrician and immediately revived her by transfusing her *with his own blood.* This occurred in 1881, six years after his graduation in medicine. A year later he was summoned in haste to his mother's bedside at Albany and arrived in time to operate at 2: 00 a. m., and save her life by draining an empyema of the gall-bladder which was about to rupture, and extracting seven gall-stones. In both instances the ablest surgeons had been in attendance. This was in 1882, and is one of the earliest deliberately planned operations for gall-

inquire with parental solicitude into the events of the day. He would sit by my bedside and, relaxing after the arduous work of the day, indulge me with his commentaries on many of the questions and problems in which we were mutually interested. He often reverted to his postgraduate days in Leipzig, Vienna, Berne, which had been destined to exercise such a profound influence upon his career as a teacher and operator. That he was held in the highest esteem in Germany is evident from the eagerness with which his publications were sought by the leading German surgical journals and societies, and from the fact that his clinic at The Johns Hopkins Hospital was the only American institution included in the list of the great clinics that enrich the pages of that leading organ of German surgical thought, Bruns' *Beiträge zur Chirurgie.* He had already been elected an honorary fellow of the Royal College of Surgeons of England, and of the Royal College of Surgeons of Edinburgh, of the Deutsche Gesselschaft für Chirurgie, and of that exclusive body, the Société de Chirurgie de Paris—all very highly prized and coveted honors, which he duly appreciated but to which he only referred in the most modest unpretentious way, and merely in connection with interesting episodes or incidents that had occurred in the course of his visits to foreign capitals. His critical comments on surgical institutions and leaders abroad, as compared with our own, were most illuminating.

It is quite evident that all his honors had come to him spontaneously, and solely through his own merit. Never by self-seeking, nor by the employment of subtle diplomatic agencies, so often the resort of men of lesser worth.

He often referred to the early experiences of his career, when he had returned from Europe full of enthusiasm, fired with a laudable ambition to improve his opportunities for the expansion of his active mind in the promising field that was assured him in New York. Throughout these friendly chats, he referred to his achievements in New York only as reminiscences, laying no stress upon the prime rôle which he had played in these epochal discoveries. In connection with the discovery of neuro-regional anaesthesia, he casually referred to a major operation, which he had performed in the winter of 1884-1885 under regional anaesthesia, and in which he had freed the cords and nerves of the brachial plexus by blocking its roots in the neck with cocaine solution. As illustrating his enthusiasm and enterprise in testing all new methods that appealed to his investigating mind,

stones in this country. These remarkable incidents will no doubt receive proper appreciation in his biography, as they reveal not only Dr. Halsted's resolute character, his courage, clear vision and strong convictions in matters which to most men of his time were still hazy and practically intangible. They also show that in matters of surgical knowledge and judgment he was way ahead of his time.

tics of this good, simple, honest, modest man of kindly approach and exquisite courtesy, who was one of the greatest surgeons of his day, should be permanently recorded.

"It is not only because he was one of the greatest surgeons of his generation that I think it a duty to render him special homage; not even because of the great debt which surgery owes him, more especially for the fundamental principles that he discovered,—as, for instance, his researches which have laid the foundation for regional anaesthesia, which he formulated and demonstrated in 1884; his introduction of the rubber glove as a vital element in modern aseptic technic in 1889,—two rightful claims to his merit which alone entitled him one of the benefactors of humanity; but, it is chiefly because he was one of the very small number of those who have been able to enlarge the field of surgery, to elevate its standards to a nobler height, and to give back to Surgery more than he had received; to give her an impress and an impulse that will be felt for years to come. Others may have been more brilliant, more seductive, perhaps, more impressive to the passing visitor; but the impressions left by spectacular operators are ephemeral, transient, and easily erased; because generally those who are called great operators only leave their imprint upon the shifting sands of time. Halsted's performance was of a different sort. It is destined to endure and to last long after him, because he dealt with the understanding of things; because he built upon the very rock upon which the foundations of surgery rest, and upon which, as a branch of the healing art, it is based.

"As an operator, Halsted, like Terrier and like Kocher, was the Father of a School of Surgery, which may be described as the Surgery of Safety; of a technic which sacrificed everything to the immediate and future success of the operation and the welfare of the patient. He put in force the most rigorous asepsis and the most uncompromising discipline in guarding the tissues from insult, by neglecting no details, no matter how small, that might compromise the issue and the thoroughness and finish with which he carried out the operative act.

"Beginning at a time when surgery was still living under the spell of the preanaesthetic days, when rapidity of execution was given the highest premium, he stood firm on the ground that the nature of the material upon which the surgeon exercised his handicraft is too noble and too precious to be insulted with impunity, or to allow even the smallest living particle to be wasted; that, to do this effectively, the surgeon must subordinate brilliancy and rapidity to safety.

"I have elsewhere related what Halsted had accomplished in this direction, and I need not rehearse the story of his life work, but I will recall that from this point of view all the surgeons of our day, who are his pupils without knowing it, owe him a thought of gratitude.

"As an investigator, Halsted understood surgery as an experimental science, aiming as his objective the greater and deeper knowledge of the laws that govern physiological and pathological life. It is difficult to express one's ideas without appearing to repeat mere truisms, but none the less, I say this advisedly, and as I feel it; the surgeon is too often only a mere technician, a man who, as the name implies, is one who works with his hands. For

such a man, his intellectual exercise is chiefly an affair of comparing his own observations with other recorded or published precedents and from this comparison drawing his deductions. This is mainly a critical exercise, but not creative work. We often hear the surgeon say, 'It is my impression,' 'I believe,' 'I feel,' 'It appears to me.' Rarely does he display the scientific spirit, the spirit of inquiry, which plunges deep beyond the surface in search for causes. He may even pride himself in being purely practical, so deeply impregnated is he with the contingent and relative character of his art. None the less, he is terribly dogmatic and his dogmatism, which is the continuous outgrowth of temporary impressions, blinds him to the fact that he has lost his intellectual independence and has become the slave of a vicious habit of mind. Halsted saw things differently. He saw a pathological and clinical problem everywhere that invited investigation and that he made the object of his experimental researches which he carried out with patience, painstaking labor and with all the discipline of a Claude Bernard. After settling on his problem, he thought it out to himself; he looked at it from every angle, but first objectively as a physiologist, then as a clinician. In speaking with him, one was surprised to discover all that he had sought to verify for himself, to control by experiment, to see clearly where the facts were leading him, long before he arrived at conclusions. On the other hand, one felt suddenly, almost as a revelation, what a huge gap there was in the classical methods of medical training and education—methods of instruction which appeal more to the memory than to reason and observation and which, in consequence, tend to waft the mind of the learner rather towards the knowledge of the past than to that of the future.

"And then one understood how the good old master, of almost timid aspect, had remained always young in spirit; so alert, so open to new ideas; so inquisitive; so investigative, in all matters that were beyond the common ken and that required thought. He seemed always ready to suggest new researches, urging the young men who surrounded him ever onward, to explore untrodden paths and to blaze new trails, remaining unto the end the inspirer and the incomparable chief of a band of exceptional men."

*
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Allow me to detain you for a brief space with a few reflections, suggested by the commentary, occasionally heard, that Dr. Halsted was not what is popularly described as a "brilliant operator," a statement which might be interpreted as depreciatory of his technical abilities by those who are unfamiliar with his aims as a surgeon and the principles that governed his operative acts. If by "brilliant" we mean the surgeon who utilizes his opportunities to dazzle the public with the prodigies of his skill, who listens for the plaudits of the multitude more intently than he does to the murmured approval of his conscience, and who burns his incense to the gods of the gallery, then, we must agree, Dr. Halsted was not one of that class. But, what do we mean by a brilliant operator? In the sense in which it is

most commonly used, brilliancy is a quality whose chief characteristic is speed, the quickness and dexterity with which an operator executes and accomplishes the operative act. This is a quality in which our forefathers excelled, to acquire which they bent all their energies, and in which they vastly surpassed us. In this respect, we, the surgeons of the present generation, can no more compare our performances with theirs than we can make comparison between the speed of a horse car and that of a twentieth century limited railroad express. But when we consider the effects of a collision between horse cars, on the one hand, and railroad trains, on the other, including the wreckage that follows in each case, we may form some idea of the relative effects of speed as applied in the cyclonic operations of the older surgery and the calm but sure and safer motions of the surgery of the present. Happily for us and for humanity, the time has long passed when surgical brilliancy and ability could be gauged by the clock, or when the relative merits of surgeons could be estimated by the rules of the prize ring or the authority of the Marquess of Queensbury. That was well enough in the dim days of antiquity, in the days of Galen and Celsus, when limbs of conscious men were amputated with an axe or a guillotine; or in much later days, when a Lisfranc, a Dieffenbach, a Lizars, or a Liston, could disarticulate a hip in five minutes or less, provided that in the flourish of blades, one or more of the assistants were not put *hors de combat* by the lightning maneuvers of the operator; or that one could say of a modern master what was said of Fergusson, who, in lithotomy, proceeded with such lightning speed and skill that someone advised a prospective visitor to his clinic to, "Look out sharp, for if you only wink you will miss the operation altogether!"

Then, time was everything, and any procedure that would relieve the patient of his encumbrance by the shortest route was at the highest premium. Before the discovery of anaesthesia, the surgeon had to be a man with a heart of steel in order to carry on his work of relief in an atmosphere reverberating with shrieks and yells, lurid with blood, and laden with the germs of disease and death. Then, indeed, he was best surgeon who could slash off an offending limb in the quickest time. Then, indeed, brilliancy consisted in speed, speed at any cost, and the price of speed was high. As late as the early nineteenth century, the death rate was enormous, full 95 per cent and over for the hip; 70 to 80 per cent for the thigh, and so on. At present, by the modern methods of safety, it has fallen to an insignificant and negligible figure, in so far as the operative act is concerned. However, do not misunderstand me as depreciating the quality of speed when this is not a mere race for a record but is the legitimate outcome of dexterity, knowledge, system and method; the outcome of long experience and faithful practice in surgical exercises.

But, I do not reckon speed as brilliancy when displayed chiefly, if not solely, for spectacular effect; when it is exhibited at the expense of security, and when appraised as skill it is rated above caution and judgment at the hazard of the patient's highest interests.

Let us not forget that Surgery, as it is known today, was a *terra incognita* to the most daring and skillful surgeons of scarcely half a century ago. Operations that are now a part of the daily routine of every well established hospital would have seemed incredible to even such relatively modern masters as a Mott, a Bigelow, or a Gross and other renowned contemporaries of this period, who would be astounded at the temerity and seeming foolhardiness of their successors.

Professor Halsted, himself, has told us (Yale Address, 1904) that "in 1876, the year I first walked the wards of Bellevue Hospital, New York, the dawn of modern surgery in America had hardly begun." The discovery of ether was not so old as to have obliterated all traces of the surgical rule, "*Tuto, Cito et Jucunde,*" but the rapid method of operating was slowly giving place to safer, more conservative and deliberate procedures. In fact, it was not until a whole decade had elapsed after the introduction of antiseptic surgery by Lister (1878 to 1888) that the changed conditions wrought by anaesthesia, antisepsis and asepsis were actually realized by the mass of the profession. It was only then that the systematic invasion of the great body cavities began and when the pelvis, the abdomen, the thorax, and the cranium gradually surrendered their contents and became amenable to the laws of surgery.

With anaesthesia and asepsis as the master keys, experimental surgery received a new impetus and the horizon of surgery rapidly expanded. Roentgen's discovery of the x-rays then came in 1895-'96 to inaugurate a new epoch in surgery and, by illuminating the body, incredibly multiplied the indications for surgical intervention. The rays and the collaboration of the physiological, biochemical, bacteriological and pathological laboratories have all combined to so transform the entire face of surgery that it is no longer recognizable in the light of its ancient portraitures.

The number of operations has not only multiplied[3] but new operations have been added and are being devised which could not have been attempted

[3] In his previously mentioned Yale Address, 1904, on *The Training of the Surgeon,* Professor Halsted, in drawing a parallel between the old and the new surgery, called attention to the small number of operations performed fifteen years before the date of his address—that is, thirty-four years ago—and their progressive and enormous increase ever since that time. He quoted the pre-Listerian experience of Billroth, Thiersch and v. Mikulicz to show what comparatively little operating was done in the great hospital centers of Austria during the forbidding days of sepsis and which subsequently, after Lister, became the theatre of the greatest surgical activity. In

in the pre-Listerian period and which were unthinkable and entirely beyond the conception of the older operators. Again, we should remember that many of the most difficult and dangerous operations, made possible through the advances of contemporary surgery, are still only made safe by the exercise of the greatest caution coupled with most consummate skill.

Such undertakings consume time and, if speed is to be the criterion of brilliancy, the surgeon who performs these operations—no matter how successfully—can never be called "brilliant." And it is precisely this class of cases in which Professor Halsted was engaged!

According to my understanding, brilliancy in surgery lies more in the results of the surgeon's intervention than in the immediate act. To my mind *he* is the most brilliant surgeon, who, in equality of circumstances, saves or prolongs the greatest number of lives and who restores his patients to health in the shortest number of days.

The brilliancy of the operator should not be appraised by the time he consumes in the performance of an operation, but by the effect that follows its achievement; not in the mere recovery of the patient from the immediate operative act, but in the way in which he recuperates; in the length of time required for his recovery; in the period demanded to restore him to usefulness, and, above all, in the permanency of the cure which it accomplishes.

It is in this manner that I would rate and compare the brilliancy of surgeons, and it is from this viewpoint that Halsted is considered one of the most brilliant and greatest surgeons of his time. It is the sort of brilliancy

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1900, v. Mikulicz wrote him from Breslau: "When I was a student in Vienna, there were days, particularly in winter, when not a single operation occurred in the University Clinic, so scarce was the operative material." Quoting the statistics of the Massachusetts General Hospital, he states "that in the entire decennium prior to the discovery of anaesthesia, only 385 operations were performed in the hospital—an average of 38.5 operations a year. In the first decade subsequent to the employment of ether, 1893 operations were performed—an average of 189 per year. In the decade preceding Lister's visit to this country (1876), from 1868 to 1878 there were 7696 operations. In the next decade only 10,118 operations were performed, but from 1894 to 1904, there were 24,270. In the single year 1903, over 3000 operations were performed in the same hospital." The Boston City, Roosevelt, and New York Hospital showed an increase in similar proportion, and this experience is repeated all over the world. The Charity Hospital of New Orleans, an institution which dates its existence to 1832, shows a record of only 172 operations in 5309 admissions during the year 1881, or a little over 3.2 per cent of the total patients admitted, and of these, 72 were amputations, 23 incisions for abscess, 18 extractions of bullets. *One single laparotomy.*

In comparison, we find that in 1923, 42 years later, in a total of 20,565 admissions, there were 16,405 operations, an increase of 79.7 per cent! Practically 80 per cent of the patients admitted in 1923 had furnished indications for surgical intervention! In other words, the treatment of disease in the hospital, which in 1881 had been a little over 96 per cent *medical* or *pharmacal*, in 1923 became 80 per cent surgical.

at which he aimed and with which he sought to imbue his pupils through his teachings and example. It is the sort of brilliancy for which every conscientious surgeon—who places his patient's welfare and the good repute of his profession above the vanity of his own flesh, should strive.

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It has been said that Dr. Halsted leaned more to the Science than to the Art of Surgery. This no doubt, so far as his natural inclinations were concerned, is true; but it is difficult to decide which of the two he benefited the more. When we consider what he did for Surgery as a craft and compare the technic of Surgery as he found it when he made his first appearance in the surgical arena scarcely more than forty years ago, and how he left it at his death; when we consider what he did for the three fundamentals of Surgery—haemostasis, anaesthesia and asepsis, in each of which he was not only a pioneer but an innovator, whose discoveries have, in many ways, transformed the entire face of the handicraft of Surgery, we have, indeed, reason to pause before expressing judgment.[4]

Need I cite examples to prove Professor Halsted's inventiveness and his influence in remodeling and recasting the older technic of Surgery as he

[4] Those who have not been privileged to see Dr. Halsted actually at work in his clinic may be able to gain an insight into his qualities as a technician by reading his paper, admirably illustrated by Broedel, in the *Journal of the American Medical Association* for April 12, 1913. In this paper, Dr. Halsted gives a most interesting account of the several methods which were peculiar to his clinic and which he originated. In this he gives convincing reasons for his preference for fine silk over catgut, and his results amply justify this preference. The history of the rubber glove as introduced by him in 1890, now universally recognized as the most important adjunct in the practice of surgical asepsis, the "boiled hand"; his use of gutta percha tissue for the protection of granulating wounds and for the prevention of adhesion of dressings and drains to the tissues (the present cigarette and cigar drains, so generally used, are of his making), and the use of silver foil and a number of ingenious and original modes of suture, are all described in Dr. Halsted's inimitable style. His use of fine straight cambric and milliner's needles, split-eyed, which were kept threaded with fine silk in long rows on sterile towels ready for immediate use, was a distinct peculiarity of his clinic. In this connection, Dr. Adrian S. Taylor, Professor of Surgery at the Medical College of Pekin, has contributed a paper (*China Med. Jour.*, xxxv, September 5, 1921), which will prove interesting to those who desire a detailed account of Dr. Halsted's methods, especially in the use of silk in surgery, as they are now practised by one of his most successful followers in the far East.

Garrison in his *History of Medicine* (1913, p. 264) admirably sums up Professor Halsted's accomplishments as a technician in the treatment of surgical wounds: "Quietly and unobtrusively, Halsted has taught the perfect healing of wounds which has been nowhere more beautifully illustrated than in his clinic."

found it, and how much he did to elevate it to the present marvelous state of efficiency? But if this is what he did to improve the methods that are fundamental and common to all modern operations, how can we question his profound interest in the art of surgery in the face of the evidence that he has given us of his perpetual concern in improving and perfecting the art as applied to more complex and major operative problems? Need I recall what he did when he revolutionized the surgical treatment of cancer of the breast scarcely a quarter of a century ago? Did he not show then, by the thoroughness of his methods, that the older technic of the operation could be so greatly improved that the percentage of local recurrences—which had up to that time ranged between 59 per cent (Volkmann) and 85 per cent (Billroth)—had dropped in his hands to the low figure of 6 per cent, and if the regional recurrences, away from the field of operation, were included, the combined total of local and regional recurrence, after three years' observation, did not exceed 22 per cent!

The publication of Professor Halsted's first paper in 1895, which described the details of his technic and which showed the results that he had obtained by his method since 1889, brought with it a new message of hope for the victims of cancer and stirred the surgeons of the world with renewed ardor in the pursuit of this implacable disease. His results, as first published, clearly show that the old traditional saying, "Cancer of the breast is operated upon, but not cured," was erroneous and that by operation the disease could be positively eradicated from its original focus of invasion. In other words, the doctrine that cancer is primarily a local disease and can be permanently rooted out, if only attacked before it has migrated to inaccessible localities, was now proven to be true far more conclusively than ever before. But even more, his results showed that when it had advanced to what were usually regarded as its impregnable intrenchments, the apex of the armpit and the neck, there was still hope of cure, if the operation was thoroughly performed, as he did it. The result of Dr. Halsted's work was that he synthetized the best points in the technics that had been suggested by the most advanced workers and he added new principles and procedures which contributed to the thoroughness of the extirpation. It was in the completeness of his method that he achieved a success which set a new pace in the progress of breast surgery, and established a standard of efficiency which had no precedent in the history of this malignant disease.[1]

[1] In an admirable study of "Cancer of the Breast," published in Paris in 1913, Baumgartner thus refers to Dr. Halsted's work:

"By combining and selecting the best suggestions offered by the most advanced operators [and adding many new and important details of his own] the American surgeon, Halsted, elaborated a surgical technic which gave a powerful impulse to

There are many of us who recall "an amputation" of the breast for cancer, as it was classically performed in the late seventies and early eighties. The operation was then a mere mammectomy, performed in fifteen or twenty minutes, or less, with a few rapid and sweeping strokes of the knife. It was a quick, "brilliant" but bloody affair, in which the diseased mamma and underlying fascia were removed, with here and there an obviously diseased axillary gland. There was no effort to remove the breast and tributary areas in block dissection, or systematically to pursue or ferret out the disease in all its known hiding places or routes of travel. The wounds were usually easily closed as there was ample skin left to cover the incision completely without leaving bare surfaces.

Then the operation was performed chiefly for palliative effect—only with the hope of prolonging life, but not for cure. At best, the prolongation of life after operation was short. Sir James Paget, in an early publication, estimated this gain of life at four months. In a later paper, he extended the average postoperative expectation of life to twelve months. Other observers of the same period estimated it at ten months (Gross), thirteen months (Morrant Baker), twenty-two months (W. R. Williams), thirty-one months (Sibley). Quite often, the disease recurred in the wound before it had time to heal. Some surgeons of the greatest experience (such as Agnew) frankly admitted that they had never been able to cure a cancer of the breast by operation or by other means. Many surgeons did not share in these extremely pessimistic views and there were individual groups of statistics which showed the error of this conclusion. In fact, many patients survived not only three years without recurrence (which Volkmann had proclaimed as a test of "cure") but five and more years. These results, however, were exceptional and it was only after Halsted had enunciated the principles upon which his operation was based and after its feasibility had been demonstrated that the number of cures of three, four, five years and much greater duration multiplied in all the clinics of the world until now they have ceased to be a novelty and can no longer be counted.

While the cure of cancer in the breast and elsewhere is dependent upon innumerable factors entirely unconcerned with mere surgical technic and still remains a problem which awaits solution and intensely preoccupies the minds of all surgeons, the fact remains that, in spite of the great gains that in recent years have been made in its treatment by the acquisition of radium

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a more radical and extensive extirpation of cancer of the breast. The operation he devised was quickly adopted, wholly or with variations, by the majority of surgeons the world over. . . . . Halsted's operation, or any other that approaches it, which is based upon the principles that govern it, is amply justified by its [superior] results, as shown by all published statistics." (A. Baumgartner, Maladies de la mamelle. *Nouveau Traité de Chirurgie,* Le Dentu-Delbet, 1913, xxlii, 270.)

and x-ray therapy, the only hope for a victim of cancer of the breast lies in the *early* and thorough extirpation of the disease by the knife, in the way planned and carried out by Halsted.

No one who has been privileged to see Dr. Halsted at work on a cancer of the breast, especially during the period between 1895 and 1908, when his publications had attracted many visitors to his clinics to study his methods, could fail to recognize the reason for his extraordinary success. Deeply interested in his work and absorbed in all its details, whether operating himself or directing his staff of well-trained and brilliant assistants, his delicate but far reaching dissections, by which he pursued the disease relentlessly, without regard to esthetic effect or plastic union; his minute and almost fastidious precautions against infection and haemorrhage, controlling the smallest bleeding point so that the total blood loss throughout the operation was negligible; his skill and nicety in covering large skin defects with autogenic skin grafts in a way that has scarcely been equalled and has never been excelled, and his final dressing of the wound, covering it with silver foil and with immobilizing plaster dressing, gave the impression to the onlooker that he was seeing the performance of an artist close akin to the patient and minute labor of a Venetian or Florentine intaglio cutter or a master worker in mosaic. Yet this task, which with all its discipline and method often consumed two and three hours, was practically shockless and bloodless and was followed almost invariably by recovery.

In May, 1907, he reported to the American Surgical Association, 232 cases of cancer of the breast operated upon in The Johns Hopkins Hospital by his method, with a total postoperative mortality at the hospital of 1.7 per cent! Of the total number, 89 patients (42.3 per cent of 210 traced cases and 38.3 per cent of 232) were living, free from recurrence and apparently cured, three to five years after the operation.[6]

[6] Dr. Bloodgood, to whom Dr. Halsted often "expressed his obligation for his efficiency and inexhaustible zeal in collecting the statistics of his operation, year after year, for so many years" further elaborated (in 1908) the statistics of his Chief as follows:

"The statistics in Halsted's clinic up to the present time show among 210 cases, in which three years and more have passed since the operation, that 42 per cent are apparently well. If we consider the cases in which the axillary glands, studied microscopically, showed no evidence of metastasis, 61, or 85 per cent, are well. In cases in which the axillary glands showed metastasis (110), 30 per cent recovered, free from recurrence for three years. When the glands in the neck showed metastasis (40 cases), only 10 per cent remained well for three years.

"In all of these groups, metastasis has been observed after an interval of three years of apparent cure. Such late metastases may take place up to eight years after operation. Excluding these case of late recurrence, the number of definitely cured in these three groups is reduced to 75, 25, and 7 per cent, respectively, or for all cases together, 35 per cent." (*Amer. Jour. Med. Sciences*, February, 1908.)

Anyone seeing Dr. Halsted at work was impressed with his "capacity for taking infinite pains." When he had finished his task, the departing visitor realized that Surgery, in his hands, had made her supreme effort to save the victims of cancer of the breast.

The same interest, originality and practical value is displayed in the technic which he evolved for skin grafting, for the suture of wounds, for the radical cure of hernia, for the resection and suture of the intestines, for the drainage and suture of the common bile-duct (at a time when most men were limiting their interventions to the gall-bladder and the cystic duct[7]). His operation on the thyroid for the cure of goiter remains today a triumph of surgical technic. His most delicate and highly anatomical procedure of the ligation of the inferior thyroid arteries which, in spite of its superiority, few men have adopted, because the upper bipolar ligations are so much easier. His success in the ligation of the great and most dangerous arteries (aorta, innominate, subclavian, carotid, iliac). His ingenious device for the partial and progressive occlusion of the aorta and other great vessels in the cure of aneurism,[8]

[7] In February, 1898, Dr. Halsted performed the first recorded and successful operation for a primary carcinoma of the papilla of Vater. The patient was a woman sixty years old. In this operation, probably the most difficult and dangerous in hepatic and intestinal surgery, he excised part of the duodenum (nearly its entire circumference) pancreas, common bile duct and pancreatic duct, in order to give the little growth, no larger than a pea, a wide berth. After the excision of the tumor, the operation was completed by a circular suture of the duodenum and transplantation of the common duct and pancreatic duct (Wirsung) into the line of suture. Two months later he supplemented the operation by creating an anastomosis between the gall-bladder, cystic duct and duodenum (cholecystduodenostomy). The patient recovered fully from the operation, but finally succumbed months after to a recurrence of the cancer in the pancreas and the cystic duct.

This, at that time, a unique case, was reported together with a number of other remarkable operations in his "Contribution to the Surgery of the Bile Passages, Especially to the Common Bile Duct," read at the Suffolk District Medical Society, Boston, May 3, 1889 (*Johns Hopkins Hosp. Bull.*, January, 1890).

[8] Dr. Halsted was the first surgeon to ligate the left subclavian in its first division successfully (May 10, 1892). He again performed the same ligation (intrathoracic) successfully, on April 26, 1918. In this case (a huge subclavian aneurism), he also ligated simultaneously the left carotid, ligating both vessels near their aortic origin. This is probably the largest subclavian aneurism ever operated upon. Two years after the ligation he excised the sac, which had remained and was beginning to relapse—also with complete success.

He had ligated the subclavian, in all, six times for aneurism, including two ligations of the first division of the left subclavian, followed in both instances by a secondary extirpation of the sac. "The patients all recovered ideally without gangrene or added loss of function; the wounds all closed without drain, healed *per primam*,

all of these are living, palpable testimonials of his love of the art as well as the science of his profession."

In every region of the body, in addition to the extremities, and in every advance that has marked the progress of surgery in the last thirty years, we find the impress of his hand and the reflex of his brain. In the abdomen, in the thorax, in the neck, in the extremities, are stamped the indelible marks of his passage, always moving onward in search of new discoveries and new conquests.

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and, in all, the aneurism was cured" (Ligation of the Left Subclavian, *loc. cit.*, p. 15). He cast ligated the innominate five times, all the patients recovering.

He was the first to occlude successfully the thoracic aorta for high abdominal aneurism with a partially occluding aluminum band (December 18, 1906).

The thorax was opened and the aorta exposed under positive pressure with an apparatus devised by his assistants, Foltz and Fisher, and he successfully applied the band 1 cm. above the diaphragm. Twenty-three days later, he applied another aluminum band to the abdominal aorta of the same patient, distal to the aneurism and below the inferior mesenteric artery. The patient survived eighteen days after the second operation. In another case he again constricted the abdominal aorta with an aluminum band on February 22, 1909, for an enormous aneurism of this vessel. The band was applied above (cardiac side of) the renal arteries. The patient succumbed on the forty-first day from infection of the aneurismal sac.

In the two operations on the aorta performed by Dr. Halsted, the fatal termination was due in each case to unavoidable complications, but not to defects in the technic.

"Dr. Halsted's deep interest in matters of pure technic remained undiminished to the very last. His paper on "Blind End Circular Suture of the Intestines, Closed Ends Inverted and the Double Diaphragm again Punctured with a Knife Introduced *Per Rectum*," was published in the *Annals of Surgery* for March, 1922, six months before his death (September 7, 1922). Of this procedure he wrote me in a personal letter (August 24, 1921): "A few days ago I sent you a package of photographs made by Max Brödel, to illustrate a clean and very simple method of making an end to end intestinal suture which I worked out last winter. This operation was performed upon 40 to 45 dogs (large intestine) by others as well as myself (Reichert, Holman, Mont Reid) and without fatality. **By no other method have I obtained such ideal results.** To test the relative merits of the various methods of suture one should make an early examination of the peritonaeal cavity twelve, twenty-four, and forty-eight hours after the operation. Only by these early examinations can we get an idea of the reaction and of the part played by Nature in overcoming the errors **and bad methods of the surgeon.**"

This contribution and his paper on the "Replantation of Entire Limbs Without Suture of the Vessels" which appeared in the *Transactions of the American Surgical Association* for 1922, and in the *Proceedings of the National Academy of Science* in July, 1922, are the last contributions which he gave to the Scientific world, and it is fitting that these two papers which were typical of his attitude of mind and his habitual mode of approaching surgical problems should have appeared almost simultaneously at the close of his career, so true were they to his two paramount interests in his professional life, the culture of Surgical Art guided and controlled by Experimental Science.

In the surgery of the brain and nervous system, in which his literary contributions figure less prominently, it is none the less *his* technic, *his* methods and doctrinal ideas of thoroughness, scrupulous asepsis, absolute haemostasis, delicate handling of the tissues, avoidance of gross material, and artistic finish in the final closure and dressing of his wound, that is reflected in the work of his gifted pupils, Cushing, Heuer, and Dandy, to whom, in succession, he intrusted and virtually relegated the development and teaching of neurologic surgery in Hopkins.

The achievements of this department have contributed some of the finest gems to the crown of modern neurologic surgery, and while they are unquestionably due to the genius of the brilliant men who have presided over it, it cannot be doubted that the stimulus of Dr. Halsted's example as an investigator, his proximity, and the suggestiveness of his observations have served to spur the men whom he had chosen for this special task, to their best efforts.[10]

Dr. Halsted attacked every problem that came before him right at the foundation. He was not satisfied with the mere superstructure, with the shaft or capital of the column. He would not rest until he was assured of the security of its base, and then when this was done he would build a shaft and capital of Corinthian beauty, so finished and perfect in all its parts, that the world looked on with admiration when he had finished his work.

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The tendency of surgery today is to lean too much towards mere craftsmanship, mere mechanical expression, mere technic. Admirable and necessary as is the cunning of the hand, its obedience to command is not all. Something more is required. As stated by Sir T. Clifford Allbutt, the most learned living exponent of medicine in England, in his memorable address "On the Historical Relations of Medicine and Surgery," delivered in this country nineteen years ago:

"The union of art and science is far from being, as too often we suppose, one merely of the wind and helm; it is one rather of wind and wing. How

[10] In confirmation of the above statement and of the suggestiveness of Dr. Halsted's observations, the following quotation from one of Dr. W. E. Dandy's early contributions on "Ventriculography Following the Injection of Air into the Cerebral Ventricles" (*Annals of Surgery*, July, 1918) would seem appropriate:

"*It is largely due to the frequent comment by Dr. Halsted on the remarkable power of intestinal gases 'to perforate bone,' that my attention was drawn to its practical possibility in the brain.* Striking gas shadows are present in all abdominal and thoracic radiograms. From these and many other normal and pathological clinical demonstrations of the radiographic properties of air, it is but a step to the injection of gas into the cerebral ventricles—pneumoventriculography." This is one of the many examples of how Dr. Halsted scattered about his germinal ideas.

these two functions, science and craft, hand and mind, should live in each other, we see in the fine arts, in the swift confederacy of hand and mind, in Dürer, Michael Angelo, Velasquez, Rembrandt, Watteau, Reynolds, Watts, only to mention the great masters of the past. [Equally as well in the domain of music, Liszt, Mozart, Shubert, Haydn, Beethoven, Chopin, and others who have excelled in imagination and composition as well as in pure technical execution. R. M.]

"The infinite delicacy of the educated senses is almost more incredible than the compass of the imagination. When they unite in creation, no shadow is too fleeting, no line too exquisite for their common engagement and mutual reinforcement. The craft of a Verrocchio becomes the magic of a Leonardo da Vinci and Michael Angelo; in genius perhaps the greatest craftsmen the world has ever seen, they were as skilful to invent a water engine, to anatomize a plant, or to make a stone-cutter's saw, as to paint the lineaments of the soul and to build the dome of St. Peter above the clouds of Christendom."

It is the harmonious unison of mind and the senses, the hand and the head, science and craft, exhibited in the supermen who have exalted the fine arts, from antiquity to the present time, that we find the ideal, difficult to attain it is true, that should be in the mind of those who aspire to the mastery of our profession.

Without pretending to soar with genius to the heights of the empyrean, which is given only to a chosen few, the surgeon, as an exponent of the greatest of the liberal arts—the sculptor and moulder of "the human form divine"—needs cultivating the subtle touch, the conscient finger and the obedient hand even more than the sculptor, the painter, the musician or other interpreters of art in baser materials.

But, even more, he needs the broad vision, the cultivated imagination, the catholicity of artistic taste and human sentiment, that give to his manual accomplishments the attributes and qualities that glorify the hand in the higher arts. To *do* all this and to *be* all this, the Master Surgeon must be a man of mind, a man of thought, a man who knows his province, the human body, as a whole and not only one of its parts.

That grand old Master Chirurgeon, Henri de Mondeville, as far back as the thirteenth century, seven hundred years ago, said:

"It is impossible to know perfectly the part, if one is not acquainted with the whole, even in a gross way (*grosso modo*): so it is impossible to be a good surgeon if one is not familiar with the foundations and generalizations of medicine. On the other hand, as it is impossible to know the whole perfectly if we are not acquainted in a certain measure with each of its parts; it is impossible for anyone to be a good physician who is absolutely ignorant of the art of surgery, with a knowledge of its possibilities and its limitations."

It is in this sense that the surgery of the twentieth century is ploughing its way to the fulfilment of its greatest destiny. It is in this way that the art of the surgeon, guided by the light of science, has risen from a low state of almost abject subserviency to its present commanding position. It is by following in the wake of scientific progress, by utilizing every advance in each one of its elementary and ancillary branches—anatomy and histology, biology and physiology, physics and chemistry, pathology and bacteriology—that surgery has sought and found light in the solution of its many and complex problems.

It is with this understanding and in this sense that our great friend understood surgery. It is in his broad comprehension of and in his capacity to utilize the data furnished by the collateral sciences in their application to surgical problems, that Professor Halsted occupies a unique and prominent position in the surgical world, and that gives enduring luster to his fame.

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The problems of the vascular system, especially of aneurism, had a great fascination for Dr. Halsted [11] and on these he brought to bear all the resources of his keen critical faculties [12, 13] and of his splendid training in anatomy, physiology, and pathology, which he invariably supplemented or initiated by illuminating experiments which he performed himself or with the col-

[11] Dr. Halsted's interest and the importance he attached to the surgery of the vascular system is understood in the light of the following paragraph. "True also it is, as I have so often said, that the surgeon's method of dealing with the blood vessels is a criterion of his proficience in his art" (Ligation of the Left Subclavian, *loc. cit.*).

Dr. Halsted evidently agreed with Ballance and Edmunds in their monumental work on the "Ligation of the Great Arteries in Continuity," (1891), when they began their chapter on the history of the ligature by stating that "the surgery of the arteries is the very foundation of surgery."

[12] Dr. Halsted's reflective mind and philosophic attitude toward surgical problems are well illustrated in the following passage from his masterly monograph on the "Ligation of the Left Subclavian Artery": "What surgeon called upon to treat a large aneurism of the neck or groin has not experienced the disturbing sensations which only such tumors can arouse? When confronted with an inoperable malignant neoplasm one feels the great pity of it, but not, as in the case of an aneurism, a peremptory challenge to face the exigency and cope promptly with a situation demanding skilful, resourceful and possibly even a temerous intervention. Few of the surgeons to come will have occasion to be stirred as Valentine Mott must have been by his dramatic experience in ligating the common iliac artery. The surgeon of today looks rather to Science than to his art for stimulating rewards of his endeavor. In ligating the first portion of the left subclavian within the chest the operator may not, as formerly, be more greatly impressed by the magnitude and cleverness of his performance than by the miraculous effect of the ligation of the artery upon the

In this respect, Dr. Halsted's investigative and analytical turn of mind reminded one of John Hunter, for whom he had the greatest admiration and of whom he once said, "John Hunter's name is eclipsed by that of no other surgeon, and for the fame of his contributions, particularly to biology and physiology, an inextinguishable lamp will forever burn." (Yale Address, 1904.)

Not unlike Hunter, he could well say, when facing an obscure problem which could not be solved by mere theorizing, "Why think? Why not try the experiment?" How faithfully Halsted exhibits the workings of his own mind when, in speaking of Hunter, he said: "How fascinating to follow the groping in the dark and the searching light of a great mind! How refreshing, and what a lesson is his honest doubt!"

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* *

Dr. Halsted's literary productions were characterized by the same distinctive, painstaking thoroughness and attention to detail which distinguishes all his work. His major monographs on the *Surgery of the Intestines,* on the *Radical Cure of Hernia,* on the *Surgical Treatment of Cancer of the Breast,* on the *Common Bile Duct,* on the *Surgery of the Left Subclavian,* on the *Effect of Ligation of the Common Iliac Arteries,* on the *Significance of the Thymus in Graves' Disease;* his collected papers on the parathyroids, his *Operative Story of Goitre;* on the *Partial Occlusion of the Aorta and Other Great Arteries with Aluminum Bands,* are examples of contributions[14] which are universally recognized as epochal in importance, not only in virtue of their originality and suggestiveness, but because of their searching analysis of the experiences of other operators as they are recorded in the literature. His complete monographs represent an immense amount of bibliographic research; not mere compilations, but critical analyses, with commentaries and criticisms on each case which add immensely to the value of the compilation. His comments and criticisms, usually short and pithy, are always illuminating and contain the very kernel of the knowledge one is seeking, and reflect the mind of the man who knew every inch of the ground that he was treading upon.

The great labor and time required in the preparation of his opera magna necessarily limited his literary output to a relatively small number of yearly productions, but each one of these works is a landmark in the history of the

[14] No attempt is made in this address to quote exact titles or references as these will appear in the complete Bibliography which is to accompany the two volumes of Professor Halsted's *Collected Papers,* now in course of preparation by Dr. W. C. Burket.

subject. He was well aware that the surgical world had learned to expect great things of him, and he spared no labor to rise above the level of the highest expectation.

To the *cognoscenti* in the highly technical subjects which engaged his attention, the appearance of one of his books or papers was always an event which promised an intellectual feast, rich in vitamines, which was to be degustated with delight but which had to be assimilated slowly. His shorter papers gave an account of the gist and trend of his activities. His pupils and co-workers often supplemented his initial and germinal ideas which he furnished in abundance, like the acorns of a giant oak from which spring other trees, vigorous and strong with the sap of the primal trunk.

Modest, self-repressed, shunning the limelight of publicity, he never obtruded his personality or exploited his merits or achievements as claims for priority, only referring to himself in the most impersonal way and always allowing the facts to speak for themselves. In this he seems to have inherited the Baconian precept that, "A man can scarce allege his own merits with modesty, much less extoll them. . . . . Such things are graceful in a friend's mouth which are blushing in a man's own."

Cushing is right when he describes Halsted as an aristocrat in his breeding, for if there was anything that he detested most cordially it was vulgarity, coarseness and undue familiarity. Though over modest and retiring, he had a full consciousness of the dignity of his rights; "Mens sibi conscia recti" expresses his attitude of mind as he walked through life.

Though shy and reserved and undemonstrative, caring little for the "gregarious gathering of men" as Cushing well expresses it, and living largely to himself in his home, his laboratory, and his clinic, he delighted in the company of his pupils, immediate associates and a few chosen friends. With these, he was expansive and the glow and warmth of his friendship melted whatever restraint had been imposed upon those who first approached him and who were kept at a distance by his punctilious politeness and adhesion to conventional formalities. To those who were privileged to bask in the sunshine of his friendship, the true nature of the man was revealed in all its splendor. When he allowed his mind to expand freely in confidence, without restraint, his breadth of thought, his wide culture, his intimate knowledge of the greatest leaders of the profession throughout the world, whom he met in his frequent travels, added to the amenity and suggestiveness of his conversation. Generous, liberal, and hospitable to a fault, his kindliness, sympathy, and unequalled liberality in helping the younger men to accomplish great undertakings, by encouraging them through privileges and opportunities which he secured for them, are all qualities which account in a great measure for the admiration and loyalty that is so notably dis-

played by his pupils and associates—an admiration, love and loyalty that only grew deeper and stronger as the years rolled by.

I cannot think of Professor Halsted without associating him with his pupils and collaborators. I see him as the central figure in a great historic painting. I see him as I have seen Ambroise Paré holding the ligature in hand, spurning the hot iron and boiling oil on the battlefield of Metz, as depicted in the great panel at the Ecole de Médecine at Paris. I see him as we have seen John Hunter and his pupils; as we see Claude Bernard in his laboratory in the Collège de France, as Velpeau is depicted, demonstrating a great lesson in surgical anatomy; as Billroth stands surrounded by his devoted coterie of assistants and pupils—all destined to be the greatest leaders in the Austrian and German universities. I see him like Pasteur, surrounded by his pupils and associates (Duclaux, Roux, Chamberland, Metchnikoff, Calmette) and again in the grand tableau representing the meeting of Pasteur and Lister in the great amphitheatre of the Sorbonne, together receiving the homage and plaudits of the assembled representatives of the civilized world (1892). I see him as Péan is seen, demonstrating the control of haemorrhage in operations by forcipressure at the Hôpital International. I see him as v. Bergmann, head of German surgery, operating at the Charité in Berlin surrounded by his now famous pupils; as Felix Guyon and his staff at the head of the great school of genitourinary practice at the Hôpital Necker; as Trousseau, surrounded by a group of his pupils, all exceptional men and teachers, all attached to him by ties of the deepest affection. I think of him as I see Gross at Jefferson; Agnew at the Pennsylvania Hospital; Bigelow at the Massachusetts General Hospital. These are great historic pictures, which we have all seen and admired not only because of the tributes that the masters of one art have rendered to the masters of another; not only because of the historic association, which reminds us of the wonderful evolution and progress of medicine, nor because of the inspiration that they give to succeeding generations, but, even more, because of their symbolic significance; by the message that they bring to us from the torch-bearers of humanity, whose burden is to transfer the undying fire of progress from one generation to another. These historic pictures, in the light of this interpretation, suggest the familiar lines: ". . . . The torch: Be yours to hold it high. We shall not sleep, if ye break faith with us who die!"

The Evangel warns us: "As ye sow, so shall ye reap."

Professor Halsted died without offspring, but Nature, as if repentant for her unkindness, endowed him with a brain of prodigious fertility from which has sprung a numerous intellectual family of supermen. Dr. Halsted has given proof of his genius in many ways. He was great in his art. He

was great in his science. He was great in his rare appreciation of the unity of the art and science of surgery and of the correlation of the medical sciences in general, which gave him a unique distinction as a teacher of surgery. He was great as the father and founder of a school of surgery which since its existence has stood unsurpassed in surgical scholarship, in surgical craft and in the attainment of surgical ideals and achievements. But in none of these was he greater than in the selection of the group of young men whom he chose to carry on his apostolate and to transmit his teachings.

"By their fruits shall ye know them," said the Evangelist, and by the seed of his culture and nurture the world now knows no richer harvest.

As I recall the great attributes of mind so characteristic of our departed friend, and remember the singular elevation of his thought, I find him in notable harmony with Carlyle's brief sketch of man's place in the universe: "He is of the Earth, but his thoughts are with the stars. Mean and petty his wants and his desires, yet they serve a Soul exalted with grand and glorious aims—with immortal longings, with thoughts which sweep the heavens and wander through eternity. A pigmy standing on the outward crust of this small planet, his far-reaching Spirit stretches outward to the Infinite, and there alone finds rest."

"Sleep sweetly, tender heart, in peace!
Sleep, noble spirit, imperial soul,
While the stars burn, the moons increase,
And the great ages onward roll."

REFUSION IN THE TREATMENT OF CARBONIC OXIDE POISONING[1]

Contributions to the treatment of cases poisoned by carbonic oxide, the most noxious constituent of coal and illuminating gases, are especially worthy of consideration because of the great frequency of and mortality from this form of poisoning. In Adolph Lesser's[2] tables carbonic oxide figures as the most common poison, and the one which yields the highest percentage of cases. Refusion of blood is literally a depletory transfusion, in which the blood withdrawn is returned to the circulation of the loser. Volkmann[3] in discussing exarticulation at the hip-joint, suggests the feasibility of catching the blood lost, peradventure, in this operation, and returning it to the loser through the divided femoral vein. And Esmarch[4] has, in one instance, endeavored to act in accordance with Volkmann's suggestion, but his patient died while preparations were being made for transfusion. Hueter,[5] in frost gangrene of both feet, transfused centrifugally 350 c. cm. of the patient's own blood, defibrinated, into the left posterior tibial artery; and believes that he thereby preserved a portion of the frozen part. The right foot, untransfused, underwent an extensive forfeiture. Highmore,[6] evidently not aware that it had already occurred to others to refuse blood, offers "remarks on an overlooked source of blood supply for transfusion in postpartum haemorrhage," and recommends utilizing the blood lost by the mother. Other than these, I know of no hints or attempts at refusion.

In carbonic oxide poisoning, refusion involves an additional factor—viz., the oxygenation of the poisoned blood employed—and is, therefore, an

[1] Presented at the New York Surgical Society, November 13, 1883. This is Dr. Halsted's first published contribution to surgery. See page 14.—Editor.

N. York M. J., 1883, xxxviii, 625-629.

Also: Med. News, Phila., 1883, xliii, 622-626.

Also: Ann. Anat. & Surg., Brooklyn, N. Y., 1884, ix, 7-21. (Reprinted.)

[2] Virchow's Archiv, lxxxiii, 2, p. 193, 1881.

[3] Drei Fälle von Exarticulation des Oberschenkels im Hüftgelenk. R. Volkmann, Deutsche Klinik, 1868, p. 382.

[4] H. Leisrink. Ueber die Transfusion des Blutes. Volkmann's Sammlung Klinischer Vorträge, No. 41. Landois. Die Transfusion des Blutes, p. 327.

[5] E. Peters. Die Arterielle Transfusion und Ihre Anwendung bei Eifrierung. Greifswald, 1874.

[6] Lancet, London, 1874, i, 89.

infusion of the purified, defibrinated for the poisoned, entire blood of the individual.

A most radical case of refusion is the following:

On May 5, 1883, Mr. A. S. G., aged fifty-seven, a man of medium size and good physique, was found unconscious in a stateroom of the steamer "Bristol" by the ticket taker, who observed a strong smell of gas in the room. He was taken in an ambulance to the Chambers Street Hospital, where he arrived at 9.05 a. m. The house surgeon states that, on admission, the patient could not be aroused. Respirations superficial, pulse fairly strong and 85 beats a minute. Temperature not taken. Skin pale and cold; lips slate-colored; pupils somewhat dilated. Was put in a hot-air bath, and given whiskey hypodermically. At 10.30 a. m., when I first saw the patient, he was still comatose. His eyes were partly open, and his pupils equal, slightly contracted and irresponsive to light; face ashy pale and surface of body cold. The respirations, 28 a minute, were abdominal, and so superficial that it was almost impossible to count them; pulse 96, small and easily compressible. Feeble conjunctival and plantar reflexes; other superficial reflexes absent except cremasteric on left side. Deep reflexes could not be tested because of the rigidity which existed. Both arms were flexed, the right more strongly than the left. 10.50 a. m., right radial artery exposed above wrist for about one inch, and two ligatures passed under it. A canula, introduced centripetally into the artery, was held in place by one ligature; the other was used to occlude the vessel peripherally. Through the canula 512 c. cm. of blood were withdrawn, defibrinated, strained, and kept at a temperature of about 37.5° C., in a transfusive apparatus. 11.30 a. m., temperature 35.4° C., pulse 92, respiration 22, full and dyspnoeic. Superficial reflexes well pronounced. Eyes closed, but patient can be made to open them. Rigidity of limbs has, in great measure, disappeared. 11.32 a. m., 288 c. cm. of defibrinated blood, all that could be obtained from the 512 c. cm., were refused through the canula in the artery towards the heart—centripetal arterial infusion. At 11.45 the injection was completed. Temperature 36.6° C., pulse 104, respirations 28, deep and labored. Superficial reflexes possibly exaggerated. The usual posttransfusion rigors lasted for half an hour. 12.35 p. m., 300 c. cm., withdrawn as before, through the canula, defibrinated, and mixed with 128 c. cm. of defibrinated blood taken from another patient. 1 p. m., temperature 38.2° C., pulse 128, respirations 28. 1.05 p. m., patient's pallor most striking; 192 c. cm. of the mixed blood infused. The color returned rapidly to his face when from 80 to 100 c. cm. had been injected; the change from a deathly white to a healthy red taking place in a few seconds. 1.13, temperature 39.1°, pulse 120, respirations 40. 2.30, temperature 39.4°, pulse 140, respirations 40. 5.30, temperature 37.8°, pulse 116, respirations 20.

Patient has been gradually returning to consciousness since the first venesection, and now attempts to get out of bed.

May 6th.—12.15 a. m., urine voided voluntarily for the first time since admission, it having previously been drawn with a catheter. 8.30 a. m., temperature 37° (normal), pulse 98, respirations 20; patient in good

condition, but mentally still a little dull. 4.30 p. m., patient eats well and desires to go home.

May 7th.—Intellect perfectly clear; remembers that the steward lighted the gas in his stateroom about 9.30 p. m. the night previous to his poisoning, but that it went out as the door was closed; undressed himself in the dark, went to bed, and can recall nothing of the night; has experienced none of the unpleasant after effects of the poisoning.

Allowed to go home to Wareham, Mass., about fifty hours after admission.

October 24th.—Have interviewed Mr. A. S. G. today, five and a half months after the poisoning, and ascertained that he has not had a single unpleasant symptom referable to the effect of the gas.

That this patient would have recovered without such active treatment is not improbable. It is, nevertheless, certain that the blood-letting exerted a most favorable influence, changing almost instantly the entire aspect of the case. The scarcely perceptible respirations became at once conspicuously full; in a few moments the absent superficial reflexes had returned, and the rigid arms relaxed. The body surface grew gradually warmer, and after the first infusion, the temperature had risen from 35.4° C. 36.6° C. (a rise of 3° F.). The pulse and respirations kept pace with the temperature. The first infusion prepared the subject for a second depletion, and contributed to the rise in temperature, and probably to the improved circulation. The second infusion was decidedly indicated as evidenced by the impression it produced in the patient's color.

In the light of Kühne's [7] experiments on animals it is a question whether the blood-letting alone would not have rescued all the cases of carbonic oxide poisoning in the human subject in which a depletory transfusion has been successful. Kühne (*loc. cit.*) found that venesection of itself could save life if the respirations were as much as two in a minute. From twenty-three cases of transfusion for carbonic oxide poisoning of which I have notes, twelve terminated favorably. In two (Casse,[8] 1; Lühe,[9] 1) of the twelve successful cases very small quantities of blood were transfused, and without any immediate good effects. In one (Hueter [10]) of the remaining cases attempts at depletion were unsuccessful, only a few drops of blood having been withdrawn. In three cases (Garrigues,[11] 1; Halsted, 2) the venesection exerted a decidedly favorable influence. Three cases (Badt,[12] 1;

[7] Centralblatt für Chirg., 1864, No. 9.

[8] Presse Med., xxviii, 8, 1876.

[9] Transfusion bei Kohlen-oxyd. Vergiftung mit günstigen Azgang. Deutsche Mil., Aerztl. Ztschr., Berl., 1878, vii, 263-267.

[10] Berl. klin. Wochenschr., 1870, No. 28.

[11] New York Med. Journal, March 3, 1883.

[12] Badt, Verhandlungen, D., Berl. med. Gesellschaft, 1, 1866.

Martin,[13] 1; Lehmann,[14] 1) are narrated in articles to which I have not access, and so can not arrive at any positive conclusions as to which was the more efficacious agent, the venesection or the transfusion. In one case (König[15]) the venesection (the amount of blood withdrawn is not stated) was attended with slight, and the transfusion with no success. The two remaining cases (Jürgensen,[16] 1; Saltzmann,[17] 1) were apparently benefited by the transfusion, and yet in neither is any reference made to the influence of the depletion, although from one (Jürgensen) 400 c. cm., and from the other (Saltzmann) 180 c. cm. of blood were abstracted.

Some, then, of the cases claimed for transfusion seem attributable to the venesection which preceded it; and in no instance has it seemed to me clearly demonstrable that transfusion has saved life where venesection had failed.

A few cases are reported by O. Kahler,[18] Marten,[19] and others,[20] of venesection in carboxysmus with good results; and, of the several cases which have come under my care, I will cite briefly, in proof of the efficacy of venesection, the most serious, one in which depletory transfusion was resorted to.

May 5, 1882, 10.10 a. m.—Lillie Bent, a robust girl of seventeen, was admitted to the Chambers Street Hospital, suffering from illuminating gas poisoning. The night before, on retiring, she is supposed to have blown out the gas in her stateroom on the steamer "Providence."

On admission she is said to have been unconscious, moaning, and much cyanosed. Her respirations were shallow, and her pulse rapid and feeble. Temperature not taken.

Whiskey and digitalis were given hypodermically. She was put in a hot-air bath, and hot cloths were applied to the praecordia. Flagellation and the inhalation of ammonia would partially arouse her. Artificial respiration was tried, but with what effect is not stated. She would improve temporarily under the treatment, but when left alone would return to her previous condition.

[13] Massmann (B. W.), Beiträge zur Casuistik der Transfusion des Blutes, Berlin, 1870.

[14] Massmann (*loc. cit.*).

[15] Evers, Deutsche Klinik, 8, 9 and 10, 1870.

[16] Berl. klin. Wochenschr., 1870.

[17] Fall auf Höggradig Kolosvergiftung, behandledt med. Transfusion. Finska Läkaresällskapets, Handl. Bd., 19, p. 266.

[18] O. Kahler, Virchow's "Jahresb.," 1881, i, p. 240.

[19] Marten, "Vjhrschr." f. g. Med., xxv, 1864, pp. 197-224.

[20] Henrick Jensen, in Helsingör, "Hospitals-Tidende" 2, R. i, 25, 26, 1874, reports a case of carbonic oxide poisoning which is interesting from the fact that decided reaction was observed during a brief menstruation. Strange that venesection was not suggested to the author by this circumstance.

I saw her about 5 p. m.; her temperature was 39.1° C., respirations 40, pulse 120; advised washing the stomach and large intestine with hot water for the purpose of further stimulation. 9 p. m., patient much worse, pulse feebler, more rapid and intermittent; respirations very superficial; conjunctiva insensitive, and all reflexes absent. Mouth frothy; occasional facial twitchings and grinding of the teeth; arms and legs rigid—the flexor muscles overpowering the extensors. 9.05 p. m., 204 c. cm. of blood withdrawn from left basilic vein. Upon this the condition of the patient improved marvelously; almost instantly her respirations became full and her pulse strong and less rapid. The rigidity of her limbs disappeared, her reflexes returned, and she could be aroused by shaking or speaking loudly to her. 11 p. m., attempted to transfuse entire blood from a Behier's apparatus into patient's right cephalic vein, but failed to introduce more than 30 c. cm.

May 6th.—During the night nourishment was administered per rectum. At 6 a. m. patient answers questions somewhat intelligently, and at 9 a. m., takes nourishment by the mouth.

May 7th.—Feels well, but weak.

It is difficult in any case to know precisely how much of the cure should be attributed to the treatment. When, however, a case like the one just narrated, observed sufficiently long to exclude fluctuation, assumes a decidedly more serious aspect, and then is, almost instantly, on treatment transformed into rapid convalescence, one feels justified in assigning a cause to the effect.

Many apparently severe cases of carbonic oxide poisoning are recorded, which have recovered more or less promptly when exposed to fresh air and stimulation. Some, too, where oxygen [21] is believed to have hastened the convalescence.

But if, despite these measures, the patient's condition grows constantly worse, death is virtually certain unless venesection be resorted to.

From the hour of her admission until she was bled—11 hours—Lillie Bent's condition was growing gradually worse, and ultimately became so bad that her case seemed hopeless; this, in a moment, upon venesection, was transformed into one of apparently certain recovery.

The transfusion produced no appreciable effect, as might have been expected from the small amount of blood injected. As additional proof of the value of bleeding in carbonic oxide poisoning I might allude to the case of her companion, who, occupying the stateroom with her, was like-

[21] Lanz in Biel, "Schweiz. Corr. Bl.," i, 12, 1871, p. 324.

Two cases of poisoning with illuminating gas successfully treated by the inhalation of oxygen. By Alonzo Clark. New York Medical Journal, August 11, 1883.

Lockey Stewart, Brit. Med. Journal, September 25, 1875, p. 302. Case of carbonic oxide poisoning in which the inhalation of oxygen exerted no influence upon patient's condition.

wise poisoned. Less seriously affected by the gas, he was venesected while convalescing. Maniacal and confined in a straitjacket, he was bled about 512 c. cm., and thereupon became so rational and docile that it was no longer necessary to restrain him. To cite, as I might, other less serious cases, in which the beneficial effect of blood-letting was less strikingly apparent, would be superfluous.

Why then transfuse, if venesection accomplishes so much? If for no other reason, to allow of repeated venesection. The poisoned individual should be bled freely, unless there be decided contraindications, even after, to all appearances, out of danger, in the hope of diminishing the risk of pernicious after effects.

Although bleeding of itself will probably suffice to save life in almost all cases which occur in practice, it has been demonstrated by Kühne (*l. c.*) that animals, poisoned beyond hope of rescue by venesection, can be saved by transfusion. In one of his experiments, where respiration had been suspended seven minutes, he was still able to restore life to the animal by the infusion of defibrinated blood.

Aside from experimental demonstrations of the value of transfusion, in cases beyond recall by means of bleeding, nothing could be theoretically much more enticing than the plausibility of substituting blood corpuscles capable of taking up oxygen, for such as are incapacitated from so doing by reason of the somewhat stable compound which carbonic oxide forms with their haemoglobin. Thus the much quoted and meritorious experiments of Panum [22] have led his partisans to believe in the possibility of blood substitution, and to regard the blood corpuscles as something which can be taken from one individual and *transplanted* in another.

But Von Ott [23] has shown the falsity of Panum's deductions in as much as he could obtain like results, although making use of a fluid which contained no morphological elements.

Von Ott (*l. c.*) has demonstrated, furthermore, that blood corpuscles infused into the circulation are short-lived, and that blood whether entire or defibrinated, for other reasons is not only no better than, but not as good as a 0.06 per cent saline solution for transfusion in acute anaemia. One cannot, therefore, properly speak of a substitution or transplantation of blood corpuscles by infusion of them into an impoverished circulation.

Fortunately, however, in carbonic oxide poisoning it is merely necessary to sustain the patient artificially for a brief period, and for this, undoubtedly, the infused corpuscles can serve as oxygen carriers for a sufficiently long time. For the circumstances, as Von Ott's (*l. c.*) experiments teach

[22] Archiv. f. Path. Anat. u. Phys., 1863.

[23] Archiv. Path. Anat. u. Phys., 1883, p. 114.

us, that the infused corpuscles do not become integral constituents of the new organism, but rather are destined to a more or less rapid disintegration and elimination, does not prevent them from circulating, and temporarily taking part in the interchange of gases. Clear, then, as are the indications for transfusion, auxiliary to venesection, in the treatment of the cases under consideration, the extreme difficulty of obtaining blood at all, to say nothing of sufficient quantity, has, up to the present time, classified the operation with the rarer therapeutic procedures. And we might, indeed, in the treatment of these cases, content ourselves with blood-letting, were it not that the practicability of refusion removes what has been, perhaps, the greatest obstacle to the performance of transfusion. To the investigations of Hermann, Donders [24] and Podolinski,[25] I owe the conception of refunding the purified for the poisoned blood of the victim of carbonic oxide poisoning.

Hermann [26] calls attention to the fact that nitrogen monoxide can liberate the carbonic oxide of the carbonoxyhaemoglobin, and forms a stronger combination with haemoglobin, than does carbonic oxide, and subsequently Donders (*l. c.*), Hermann and Podolinski (*l. c.*), find that oxygen or air can, in a few minutes, free carbonic oxide from haemoglobin, if passed forcibly and in large quantities through the poisoned blood.

As to the best method of infusing fluids into the circulation, good authorities disagree. Of the four possible methods, centrifugally or centripetally into an artery or vein, the question of centrifugal venous infusion is entertained only to be discarded. Hueter [27] who gives to Von Graefe the honor of being the first to draw attention to centrifugal arterial transfusion, deserves the credit of having introduced it to the profession, and strongly advocated the method.

Landois,[27] too, while contrasting, in general, arterial with venous transfusion prefers, from a physiological standpoint, the arterial, be it centripetal or centrifugal. Cohnheim [28] on the other hand, expresses himself decidedly against centrifugal arterial transfusion essentially as follows: One should surely under no circumstances inject peripherally into an artery; for the peripheral arterial branches contract with such energy against the foreign blood which is entering them, that it is often necessary, in order to overcome the resistance, to exercise pressure sufficiently forcible to rupture the blood vessels. The case is very different when one injects centripetally into an artery and employs no more pressure than is required

[24] Archiv. f. Phys., v, p. 24.
[25] Archiv. f. Phys., vi, p. 553.
[26] Archiv. für Anat. u. Phys., 1869.
[27] Die Transfusion des Blutes. Leipzig, 1875.
[28] Vorlesungen über allgemeine Pathologie, Bd. i, p. 424.

to overcome the existing arterial tension. The blood infused mingles at once with that which is already present in the artery, and flows without resistance into the first branch above, thence into its arterial and capillary ramifications, and from here under, normal venous pressure, to the heart.

Kümmell,[29] Schede's assistant, produced gangrene of the hand by the centrifugal infusion of a saline solution into the radial artery, thus giving us a demonstration of a disaster which may attend this method, and which he might have foreseen.

We are then restricted to the choice between centripetal arterial and centripetal venous infusion.

Hueter's[30] arguments for peripheral or centrifugal arterial transfusion hold good for centripetal arterial infusion. He prefers the arterial to the venous transfusion because the blood by the former method courses slower and more uniformly to the heart; because the minutest air-vesicle is retained in the capillaries, and because the danger of phlebitis is avoided.

Landois (*l. c.*) adds to these advantages another, viz., that the capillary system, like a supplementary filter, catches all foreign particles which may be present.

The essential advantages of centripetal arterial transfusion in profound asphyxia, says Landois, can be summed up as follows: (1) Arterial blood is thus most directly dispatched to the nerve centers, in consequence of which the venous blood there contained is propelled onwards into the veins; and (2) the filling of the arterial system rejuvenates the feeble circulation by creating a considerable difference in pressure between the arterial and venous systems.

Cohnheim (*l. c.*), too, from his experiments on animals, declares the central or centripetal arterial transfusion to be the least dangerous, and at the same time the most completely effectual procedure.

From a practical standpoint I am also impelled to advocate centripetal arterial infusion.

Besides the case already narrated, it has been my good fortune to transfuse by this method with most brilliant and unexpected success in two cases; one of acute anaemia, and one of septicaemia.

Joseph Hart, aged eleven years, was admitted to Roosevelt Hospital, September 15, 1882, for a compound comminuted fracture of the tibia and some of the tarsal bones. The ankle joint was involved in the injury and the soft parts badly mangled. The wheel of a street car had passed over his leg the night before. Patient is said to have lost much blood, and the cloths in which his leg was wrapped furnished evidence to that effect. The

[29] Centralblatt f. Chirg., 1882, No. 19.

[30] Langenbeck's Archiv., Bd. xii.

parents would not consent to an amputation, and the boy, although perfectly conscious and able to give an account of himself, was not in condition for it.

At 8.30 p. m. eleven or twelve hours after admission the patient was cold and unconscious, and his pulse was so rapid and feeble that it could not be counted satisfactorily. It was estimated to be about 180 per minute. I injected 192 c. cm. of a chlor-natrium solution (ClNa, 3i; H_2O, O.i), centripetally into the left radial artery, whereupon the pulse became quite full, and 135 a minute; the boy returned to consciousness, and his condition seemed to warrant an attempt at amputation—permission to do so having, meanwhile, been obtained. The administration of ether had such a bad effect on the pulse that the operation was deferred, and the leg placed in a hot water bath. Patient continued to improve and survived an amputation of the leg performed by Dr. Sands twenty-five days after admission.

On March 18, 1883, at Ward's Island, I infused defibrinated blood centripetally into the radial artery, in a case of septicaemia.

The patient, an Italian about 40 years of age, had suffered for several months from a suppurative disease of the ankle and some of the tarsal joints. For about one week prior to the operation he had, almost daily, well pro- He was so feeble that to amputate was deemed inadvisable even as a last resort. A depletory transfusion was accordingly undertaken. A stout philanthropic German offered to furnish the blood. So plentiful was his subcutaneous fat that not a vein could be seen, although his arm had been carefully constricted below the point at which the basilic vein usually perforates the deep fascia. Dissection for a vein, prolonged until even the would-be-donor appeared to be willing to have the search discontinued, failed to discover one. Thereupon the radial artery was exposed without difficulty, although our subject fainted as the incision was being made through the integument, and so necessitated the completion of the operation upon the floor. The Italian was next depleted through his right radial artery until the arterial tension was barely sufficient to throw a jet across the graduated jar into which 178 c. cm. had been allowed to flow.

Immediately thereupon 186 c. cm. of defibrinated blood was infused centripetally into the artery. In a few moments the patient's pulse had fallen to 120, which was eight beats better to the minute than before the administration of ether. The leg was then amputated just below the middle. The patient's pulse 112-114, weak, but regular and better than before the amputation.

Cardiac stimulants were of course freely administered. Slight post-transfusion rigor, and a temperature of 38.8° C. On the following morning, March 19th, the patient's pulse was 110, and temperature normal. Since then uninterrupted convalescence.

It is only just to add that I have once done centripetal arterial infusion in a desperate case of pyaemia, where the fatal termination was possibly precipitated by the operation.

If the infusion of defibrinated blood influenced unfavorably the action of the heart, it certainly was, in part, to be explained by the too heroic

depletion which preceded it. This unsuccessful attempt should not militate against the method of injecting the blood, but rather against the indication for so doing, or against the manner or extent of the depletion. The main argument of those who prefer centripetal venous to centripetal arterial infusion is that the former is the simpler. If it be true that the latter is, in any degree, the safer method, the simplicity of the former does not deserve to be considered. Furthermore, instead of being easier, I am sure that it is often more difficult to find a vein than to expose the radial artery. It was, for instance, impossible to discover a vein in the stout German referred to in this paper.

Jennings,[21] too, one of the more recent advocates of the intravenous method, without having practised the arterial, had considerable difficulty in finding a vein in one instance; and others testify to the same experience. The dangers of intravenous infusion, such as the introduction of air and small clots, and the overpowering of the heart by a too rapid injection, may be, theoretically, easy to avoid; but practically death has frequently been brought about by one or more of these causes. To the centripetal arterial infusion pertain, theoretically, none of the dangers which, practically, in the intravenous method, are far from always to be avoided. And from a practical standpoint my cases, which, I believe, are the first recorded, induce me to advocate the centripetal arterial method.

[21] Transfusion, p. 26. Balliere, Tindall & Cox, London, 1883.

CENTRIPETAL ARTERIAL TRANSFUSION[1]

I would like to ask Dr. Crile what he thinks of centripetal arterial transfusion in a case of weak heart. I remember he suggested the advisability of this on animals. Some thirty years ago, in New York, when I used to see a great many cases of carbon dioxide poisoning, we had many opportunities of transfusing the centripetal arteries. We used to take the blood of the patient, because it is very important to bleed these patients, then beat the blood with nitrogen and reintroduce it centripetally into the artery; then there is no danger of gangrene. I would like to know what Dr. Crile thinks of this form of transfusion. I have been much interested in Dr. Brewer's apparatus. We have been trying somewhat the same thing with silver tubes, but I cannot report the results, as it is in the hands of another man. Abbe, many years ago, put a glass tube in the aorta.

Now, with reference to another method of transfusion. I am not recommending it; it is not nearly so good as Crile's, but under certain circumstances I have seen in the operating room certain embarrassment and delay in transfusion. If two tubes are used, one for the vessel of the donor and one for the donee, by different operators, they can be quickly joined together. Last October we had some of these tubes made in pairs, so one could run both arteries through each tube if one so desires.

[1] Remarks in discussion of Dr. George W. Crile's paper, "Further observations on transfusion with a note on haemolysis." American Surgical Association, Philadelphia, June 3-5, 1909.

Tr. Am. Surg. Ass., Phila., 1909, xxvii, 85-86.

CENTRIPETAL ARTERIAL TRANSFUSION[1]

Dr. Klopp's admirable paper has for me an especial interest, for *my first published contribution to surgery* was an article which appeared nearly forty years ago in the Annals of Anatomy and Surgery. At the old Chambers Street Hospital, a relief branch of the New York Hospital, we saw many cases of gas poisoning, most of them contributed by the night boats plying between New York and points along Long Island Sound. In a number of instances I practised what I termed *refusion.* The patients would be freely bled and their blood, defibrinated, returned to them by way of the radial artery—a centripetal arterial transfusion. The idea of purifying and refunding the poisoned blood occurred to me on reading Hermann's Physiology. Hermann called attention to the fact that nitrogen monoxide can liberate the carbonic oxide of the carbonoxy-haemoglobin, and forms a stronger combination with haemoglobin than carbonic oxide does, and several physiologists found subsequently that air can in a few minutes free carbonic oxide from haemoglobin if passed forcibly and in large quantities through the poisoned blood.

The results in some of our cases were remarkable. Patients who were comatose would after blood letting promptly become conscious and even quite rational, and on refusion of their defibrinated and depoisoned blood would improve still further, as evidenced particularly by their color, and the force of the pulse.

Von Graefe was the first to suggest centrifugal, and Landois the first to recommend centripetal arterial transfusion. Hueter advocated arterial transfusion in preference to venous because the blood courses more slowly to the heart and the capillaries filter off air vesicles and any solid particles accidently introduced. So far as I know, these cases of mine at the Chambers Street Hospital are the only ones recorded of centripetal arterial transfusion in the human subject. It is not quite clear to me why depleting transfusion is so seldom practised in cases of gas poisoning. In these days of blood matching the procedure would be relatively simple.

[1] Remarks in discussion of Dr. Edward J. Klopp's paper, "Refusion of blood in haemorrhage." The American Surgical Association, Washington, D. C., May 2, 1922. Tr. Am. Surg. Ass., Phila., 1922, xl, 218.

THE EFFECT OF ADDUCTION AND ABDUCTION ON THE LENGTH OF THE LIMB IN FRACTURES OF THE NECK OF THE FEMUR

ADDUCTION AND ABDUCTION IN FRACTURES OF THE NECK OF THE FEMUR[1]

Dr. W. S. Halsted presented a patient with fracture of the neck of the femur with abduction, and a specimen of intracapsular fracture of the neck of the femur from a case in which there had been adduction and a quarter of an inch shortening. He called attention to the necessity of making allowance for adduction and abduction in the estimation of the amount of shortening in these cases. From certain measurements made upon dead and living subjects, he had demonstrated that, as abducting the lower limb made it measure less along the line from the anterior superior spine of the ilium to either malleolus, so adducting it made it measure more along the same line; furthermore, that, one leg being adducted, the other must be abducted to be brought parallel with it. Hence, in a fracture of the neck of the femur with adduction, the injured limb might actually measure more than the sound one: *First,* because it was lengthened by adduction; *second,* because its fellow was shortened by abduction. In the case from which his specimen had been taken he had been able to make the diagnosis of fracture, because of the recognition of these facts. The injured limb was *apparently* shortened, but, by measurement from the anterior superior spine to the malleoli, was one eighth of an inch lengthened, although a quarter of an inch shortened along Bryant's line.

The patient with fracture of the neck of the femur and abduction had limbs of apparently equal length. Along Bryant's line the injured limb measured three-eighths of an inch, but from the anterior superior spine of the ilium to the malleolus externus an inch and a quarter, shorter than the sound one. Dr. Halsted remarked, further, that, in cases in which, measured on Bryant's line, there was equal shortening, the adducted limbs would render more of a limp necessary than the abducted ones. In consideration thereof, he believed it unwise to allow the limb to remain in an adducted position.

Dr. Alfred C. Post remarked, with regard to the anatomical specimen, that it hardly seemed probable that such a degree of absorption could have

[1] Presented at the New York Surgical Society, February 12, 1884. Previous to this report the effects on measurement of abduction and adduction in fractures of the neck of the femur had not been mentioned. W. S. H.

N. York M. J., 1884, xxxix, 251.

Also: Med. News, Phila., 1884, xliv, 250.

taken place within two weeks unless there had been some before. The specimen itself would seem to indicate that several months must have passed after the receipt of the injury.

Dr. Halsted said the man asserted that he had never had any trouble about his hip joint, nor received any injury, and had never been obliged to walk with a limp.

THE EFFECTS OF ADDUCTION AND ABDUCTION ON THE LENGTH OF THE LIMB IN FRACTURES OF THE NECK OF THE FEMUR[1]

Agreed though we all are that the pelvis should be horizontal when measurements to determine the relative lengths of the limbs are made from the anterior superior spinous processes of the ilia to the malleoli, very few indeed are familiar with the facts which make it necessary. The reply, that

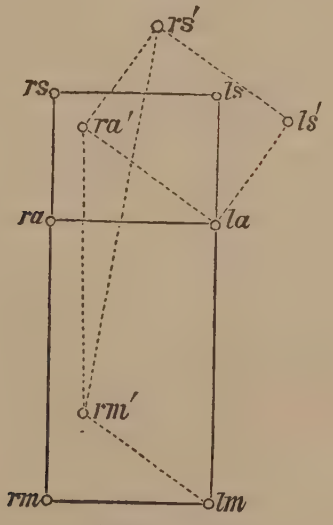


Fig. 1.

an obliquity of the pelvis causes an apparent difference in the relative lengths of the lower extremities, is true, but does not explain. It implies, to be sure, that one leg is abducted and the other adducted, and yet this of itself might be possible without leading to error by measurement.

Thus, in Fig. 1, let *rs* and *ls* represent the anterior superior spines of the ilia, *ra* and *la* the right and left acetabula, and *rm* and *lm* the right and left malleoli (external or internal). If, now, the pelvis be rotated on an anteroposterior axis passing through the left acetabulum, *la,* the right mal-

[1] Read before the Medical Society of the County of New York, February 25, 1884.
N. York M. J., 1884, xxxix, 317-319. (Reprinted.)
Also: Med. Rec., N. Y., 1884, xxv, 248.
Also: Med. News, Phila., 1884, xliv, 288.

leolus, *rm*, becomes raised to *rm'*; the right leg is adducted and apparently shortened, and the left leg is abducted. Nevertheless, the line *rs'rm'* = *ls'lm*, just as before the line *rsrm* = *lslm* did, proving that, if our diagram be correct, measurements from spines to malleoli can determine accurately the relative lengths of the limbs, notwithstanding an obliquity of the pelvis.

But we know, from observation of the earlier stages of hip-joint disease, that, if the diseased limb be adducted and apparently shortened, it will measure longer than the healthy limb; and, conversely, that, if the diseased

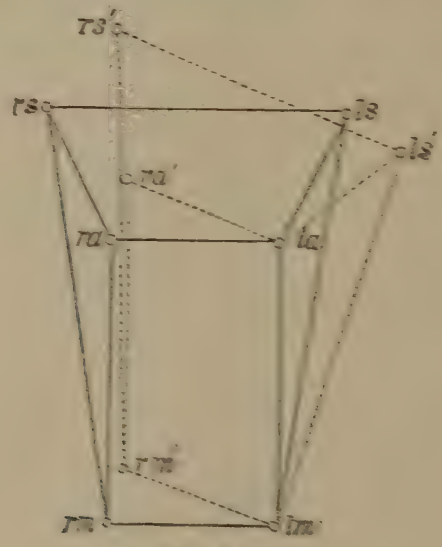


FIG. 2.

limb be abducted and apparently lengthened, it will be shorter by measurement than the sound limb.

This could not be the case if the spine, acetabulum, and malleolus of one side occupied the same perpendicular line as represented in Fig. 1. We look, then, to the skeleton for an explanation, and find that the spines are farther apart than the acetabula are. In Fig. 2 this is illustrated. Here, too, the line *rsrm* = *lslm*, provided the line *rsls* be parallel to the line *rmlm*, or, in other words, provided the pelvis be horizontal. When, however, it is rotated, as before, about an anteroposterior axis through the left acetabulum, *la*, the line *rs'rm'* measures more than the line *ls'lm*. Because, then, of the tilting of the pelvis, the abducted left leg measures less than the adducted right leg. Furthermore, the abducted left leg measures less than it did when straight, and the adducted right leg more than it did when straight, as a glance at Fig. 3 will suffice to show.

In this figure the obtuse-angled triangle *rsrarm* has, for the sake of clearness, been separated from Fig. 2, and now it is perfectly evident that when the angle *rs ra rm* is made less obtuse, as it would be by abducting the leg *rarm*, the line *rsrm''* measures less than *rsrm*; that is to say, the leg is shortened by measurement from spine to malleolus, and that adducting the leg until the spine *rs*, the acetabulum *ra*, and the malleolus *rm* occupy the same straight line, *rsrarm'*, lengthens the leg by measurement. For in the one instance (in abduction) we measure one side *rsrm''*, and in the other (in adduction) *rsra+rarm* of the triangle. A. Nélaton recognized this triangle, and pictures it in his "Éléments de pathologie chirurgicale," tome ii, p. 833.

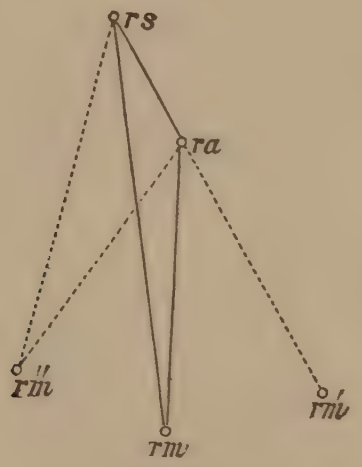


Fig. 3.

And, to quote Barwell[2] Gädechens, in 1836, called attention to the fact "that when the ilium inclines to one side, its crista must approach the trochanter of the femur; thus, though the whole thigh may sink and appear longer, the measurement between any point of the crista ilii and of the thigh must be shorter than the other limb." I do not understand why he did not (if indeed he did not) draw the complementary conclusion that adduction, up to the extent to which we have already referred, must make the limb measure longer, unless, as is highly improbable, he believed that the spine, acetabulum, and malleolus were normally on the same perpendicular, in which case adduction would make the limb measure just so much shorter as abduction through the same number of degrees would. I say "highly improbable," because Gädechens speaks of a sinking, apparent lengthening, and measured shortening of the abducted thigh. Now, appar-

[2] Barwell, "A Treatise on Diseases of the Joints, 1861, p. 304.

ent lengthening with measured shortening of the abducted limb would, if the three points above mentioned were on the same perpendicular, only be possible provided the limbs were not approximated; and if Gädechens compared by measurement divergent limbs, irrespective of the angles which they formed with the pelvis, his results could not have been sufficiently constant to enable him to arrive at the conclusions which he did. To confirm, experimentally, that adduction produces lengthening by measurement from spine to malleolus, the writer has driven nails into cadavers at the points mentioned, and found that adduction may give measured lengthening from 2 to 8 mm., and abduction measured shortening from 2 to 4 cm., or thereabouts, in different cases.

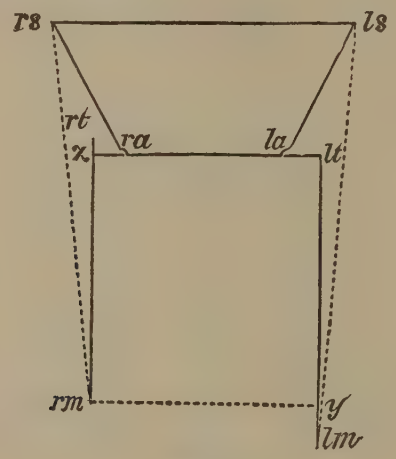


Fig. 4.

Clinically, too, in fractures of the neck of the femur, adduction and abduction probably frequently occur, and to a considerable degree. To recognize these as factors in the deformity is essential for even an approximate estimation of the amount of real as distinguished from measured and apparent shortening. Its recognition is further of importance from the treatment standpoint.

If in fracture of the neck of the femur there be neither abduction nor adduction, the pelvis will be horizontal when the legs are parallel. In such a case the apparent shortening, real shortening, and measured shortening would be practically equal. Thus, in Fig. 4, the apparent shortening $= lmy$, the real shortening $= rtx$, and the measured shortening $= lslm - rsrm$.

When, however, adduction is an element in the deformity, there will be apparent shortening, almost invariably real shortening, and possibly measured lengthening, provided the adduction be considerable and the real shortening not excessive.

This measured lengthening I have once observed in my wards at Bellevue Hospital, and had the opportunity to confirm the diagnosis at the autopsy. The case was reported recently at the surgical society, and the specimen of the fracture, which was intracapsular, presented.

It is in this particular variety of fracture, when associated with adduction, that the diagnosis might be difficult, if not impossible, unless the special features of the case were recognized.

Lisfranc and Lallemand have each observed a case of fracture of the neck of the femur in which the broken limb was the longer.

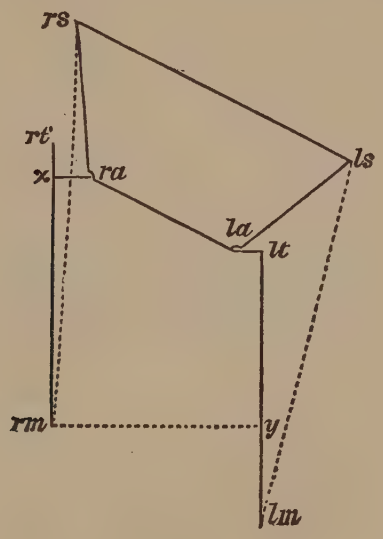


FIG. 5.

Senn,[8] referring to these cases, says that "it is *impossible to conceive* in what manner the fracture could add to the length of the limb."

He was evidently unacquainted with the points upon which the writer is dwelling.

The recognition of the adduction is furthermore of importance because, if the limb be allowed to remain in this position, the patient will surely limp when he walks, notwithstanding the fact that there may be measured lengthening and very little real shortening.

In Fig. 5 is outlined a fracture of the neck of the right femur, with adduction. The apparent shortening, *lmy,* is excessive, although the real shortening, *rtx,* is inconsiderable. The lengthening by measurement equals *rsrm—lslm.*

[8] "Fractures of the Neck of the Femur," N. Senn. "Transactions of the American Surg. Assoc.," vol. i, 1883.

Figs. 6 and 7 represent fractures of the neck of the right femur, with abduction. In 6 there is little abduction and great real shortening, and, consequently, apparent shortening. In 7, much abduction, little real short-

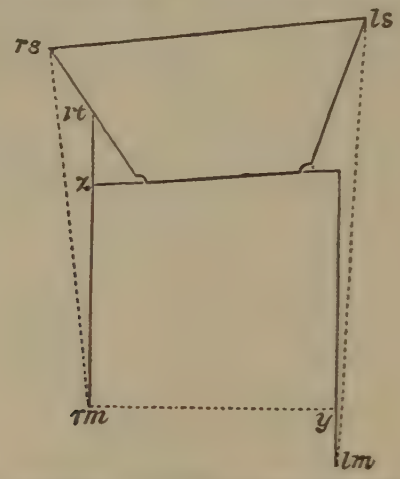


FIG. 6.—Fracture of the Neck of the Right Femur, with Slight Abduction. *lmy*, apparent shortening; *rtx*>*lmy*, real shortening; *lslm* — *rsrm*>*rtz*, measured shortening.

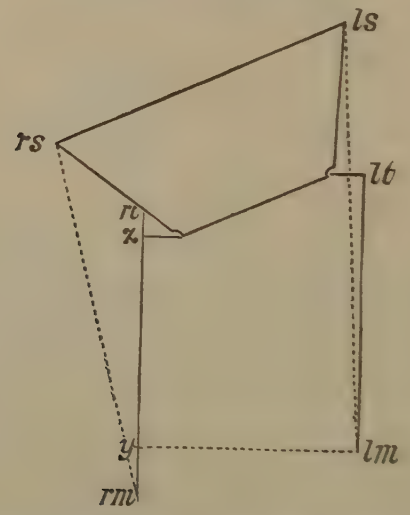


FIG. 7.—Fracture of the Neck of the Right Femur, with Abduction. *rmy*, apparent lengthening; *rtx*, real shortening; *lslm* — *rsrm*, measured shortening.

ening, and hence apparent lengthening. Although the measured shortening is greater in 7 (the case of apparent lengthening) than in 6, the patient in the case of apparent shortening (Fig. 6) would limp, and in the other

might not. Apparent shortening, consequently, is undesirable, and should be overcome if possible. Thus it becomes evident that statistical tables designed to show how much measured shortening may exist without causing a limp, and how little measured shortening occurs in many cases of fractures of the neck of the femur, are worthless unless the adduction and abduction which may have been present were recognized.

König[4] believes that the amount of apparent lengthening or shortening equals the difference in level between the right and left anterior superior

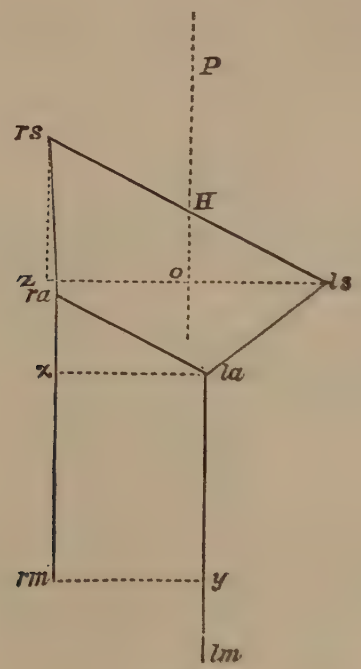


Fig. 8.

spines of the ilia. That this is not strictly accurate is shown in Fig. 8; for the line *rsz*, which represents the difference in the level of the spines, is longer than the line *y lm*, which represents the apparent lengthening. The line *rax=ylm*, but, unfortunately, cannot be accurately determined on the living subject. Bryant's line, for obvious reasons, is only to be relied upon when the pelvis is straight.

To determine, then, approximately, the amount of real shortening, it is best that the pelvis should be horizontal. For the sake of accuracy, a Volkmann's coxankylometer, or something equivalent, may be employed.

[4] "Lehrbuch der speciellen Chirurgie," vol. iii. p. 267.

Or, if it be difficult to straighten the pelvis, one might make use of a procedure recommended by Giraud-Teulon. This consists in a geometrical device for determining the distance of either one of the condyles of the femur from the center of the cotyloid cavity. The middle point of a line drawn from the anterior superior spine of the ilium to the tuberosity of the ischium corresponds quite closely to the center of the acetabulum. If, then, a triangle be formed by lines drawn between one of the condyles of the femur, the anterior superior spine of the ilium, and the tuberosity of the ischium, the length of a line let fall from the condyle selected (the apex of the triangle) to the middle of the base line (that drawn from spine to tuberosity) equals the distance from said condyle to the center of the cotyloid cavity, whatever may be the position of the pelvis or femur.

DISCUSSION

"Dr. Halsted said his remarks were directed specially to accidental fracture of the neck, and not to cases of hip-joint disease. He did not think that in the former class of cases the objection brought forward by Dr. Judson with relation to the great obtuseness of the angle formed by a line drawn from the malleolus to the acetabulum, and another drawn from the superior spinous process to the same point, was well founded in cases of the kind to which he referred, as was illustrated in the case cited. The practical value of the point made in the paper amounted to this in treatment, that by recognizing the influence of abduction the position of the leg could be changed and the patient saved the necessity afterward of walking with a limp.

"Dr. Halsted said, in regard to Dr. Judson's idea, that the angle was too obtuse to be of any practical importance, and that he believed that he was mistaken. In the case in Bellevue Hospital, which led him to make a special study of this subject, the patient stated that he had never had the slightest limp before. The apparent shortening was two inches, while the measured length of the injured limb was one-eighth of an inch greater than that of the other, and hence it was thought that there could be no fracture. He decided, however, that there was an intracapsular fracture. There were three things that he took into consideration: First, the abduction, making the limb longer; second, the adduction of the other limb, which was paralyzed, making it shorter; and, third, the fact that one limb might be naturally longer than the other. His demonstration had a direct bearing, he thought, on both diagnosis and treatment. With an adducted, impacted fracture, with apparent shortening, the patient was sure to limp."

SURGICAL TECHNIC

ASEPTIC AND ANTISEPTIC SURGERY

THE EMPLOYMENT OF FINE SILK IN PREFERENCE TO CATGUT AND THE ADVANTAGES OF TRANSFIXING TISSUES AND VESSELS IN CONTROLLING HAEMORRHAGE

ALSO AN ACCOUNT OF THE INTRODUCTION OF GLOVES, GUTTA-PERCHA TISSUE AND SILVER FOIL[1]

For a number of years I have had it in mind to call attention to the particular method of employing silk ligatures and sutures which has been practised in the surgical clinic of The Johns Hopkins University since the opening of The Johns Hopkins Hospital in 1889, but have hesitated and also been eager to do so for the same reason, namely, that our school seems to be almost alone in its advocacy of the use of this material.

Theodor Kocher, however, has for many years employed silk quite to the exclusion of catgut and our position is greatly strengthened by the support of such eminent authority.

Surgeons, old and young, those who have been active and masterful in the marvelous period of development of antiseptic surgery, and the medical student who takes for granted the healing of wounds *per primam* and the achievements of modern surgery as he does the ability to speak his own tongue, will be interested to read the words of Kocher[2] spoken in 1888. "'Away with the spray!' cried Bruns[3] some years ago—Bruns who achieved so much and who died, alas, so early—and gladly did one cast off this burden. 'Away with protective!' exclaimed Starcke[4] in an admirable essay on the treatment of wounds. But with the elimination of spray and protective there are still many of the seemingly essential features of the antiseptic technic to be discarded before the physician in general practice can be placed in that happy state of mind which pertains to the consciousness of his ability to avoid making the famous seven errors of Nussbaum. The 'away' must resound still further, and we say, therefore, primarily, away with the catgut! and also: away with all the prepared gauzes, from the

[1] This article is placed exceptionally out of the chronological order as it is the only approximately detailed statement by Dr. Halsted himself on the subject of some of the more important of his contributions to surgical technic.—EDITOR.

J. Am. M. Ass., Chicago, 1913, lx, 1119-1126. (Reprinted.)

[2] Kocher: Eine einfache Method zur Erzielung sicherer Asepsis, Corr.-Bl. f. schweiz. Aerzte, 1888, xviii.

[3] Berl. klin. Wchnschr., 1880, No. 43.

[4] Vortrag in der Berl. militärärztl. Gesellsch.

Lister gauze to the newest productions of the manufacturers of supplies for dressings.

"To what misfortunes catgut can give rise more than one communication in the medical journals of years ago has testified. In the first place von Zweifel called attention to the decomposition which took place when catgut was kept in phenolized oil as recommended by Lister. Other surgeons have confirmed the observations that one may infect wounds directly with catgut preserved in the manner mentioned and we also have at one time published the case of a woman whose death after the excision of a struma sarcomatosa was attributable to the employment of catgut which had decomposed in the phenolized oil."

Kocher proceeds to relate the disastrous experience he had with catgut from May to July, 1887. Of thirty-one operations performed in a period of seven weeks, serious infection of the wound occurred in twenty-nine.

In one of the two non-infected cases silk was employed. Hence in this particular "catgut period" only one operative wound, a small one in which were very few ligatures, healed *per primam*. Catgut being totally discarded and silk reinstated, the infections ceased. From that time until the present, except possibly for brief periods of experimentation with catgut, Professor Kocher has, I believe, employed silk. I have not heard him state his reasons for preferring silk in these days when catgut may be perfectly sterilized, but that they are sound we may be sure. I can testify to the admirable healing of his wounds.

Our method of employing silk differs quite essentially from Professor Kocher's. The silk which we use is much finer than his and we rely on transfixion to prevent the ligature from slipping.

I am unable to say precisely when it was that I definitely substituted silk for catgut. It must have been earlier than 1883, for in that year or in 1882 Warmbrum Quilitz & Co. of Berlin made for me, in glass, bobbins of my designing, to be held in the left hand of the operator during the act of ligating blood vessels. A description and illustration of these spools is given in The Johns Hopkins Hospital Reports.[5] I have employed them continuously from the time of their introduction to the present. When the operator desires to tie a vessel without tissue-transfixion he is handed a spool—not a thread cut to the length desired for a ligature. With the right hand the silk is unwound, as required, from the spool held loosely in the left. Only two or three yards are wound on each spool, but enough for the tying of many arteries; and for each operation the silk employed is sterilized only once. The armed glass spools are steamed in heavy glass test-tubes (Plate I, 1).

[5] Johns Hopkins Hosp. Rep., Balt., 1891, ii, 306.

In the winter of 1886 and 1887, experimenting on the subject of intestinal suture[6] with Dr. Franklin B. Mall, I employed ordinary, fine black spool-silk as material for ligature and stitches. Black silk was selected in preference to white because it was easier to see it on the glass bobbins and in the fresh wound, and it was also more readily identified in the healed wounds. The little black loops of the mattress or Lembert stitches made a striking picture after a time, lying more or less free under the peritonaeum along the line of the intestinal suture.

The following winters 1887-1889, in my experiments on the thyroid gland, I employed exclusively the black silk, just as we do today and have done ever since the opening of The Johns Hopkins Hospital twenty-four years ago.

The relatively high cost of catgut, its bulkiness, the inconveniences attending its use and sterilization, its inadequacy, the uncertainty as to the time required for its absorption, and the reaction which it excites in a wound, induced me to discard it completely for clean wounds in the surgery both of the human subject and of animals. From year to year and for various periods of time I have given the catgut, sterilized by the best known American purveyors of this material, a trial, but invariably with the results which we interpreted as being less perfect than with silk. Infection from pathogenic organisms can, of course, only rarely be ascribed, nowadays, directly to the catgut sterilized by our most reliable firms. With the fine silk in our wounds, which for twenty-three years have, as a rule, been closed without drainage, suppuration almost never occurs.[7] But catgut, even that which we have no cause to believe is not sterile, irritates the wound for some reason, perhaps because it serves as culture medium for saprophytic organisms which are carried into it from the deep epithelium and follicles of the skin.[8]

We have frequently observed this irritation and have occasionally had the opportunity to compare the reaction caused by catgut with that of fine silk in wounds symmetrically situated in the same patient and made at the same time.

Let the surgeon interested in making the comparison, when he has occasion to amputate both breasts for nonmalignant disease, take a running subcuticular stitch on the one side with catgut, on the other with fine silk (No. A or AA) and observe the healing wounds from day to day; or when

[6] These experiments were conducted in the Pathological Laboratory of The Johns Hopkins Hospital. Am. Jour. Med. Sci., October, 1887, p. 436.

[7] Johns Hopkins Hospital Reports, Balt., 1891, ii, No. 5.

[8] The reader is referred to the admirable work and unusually convincing articles of Dr. Y. Noguchi, Arch. f. klin. Chir., xcvi, 394, and xcix, 948.

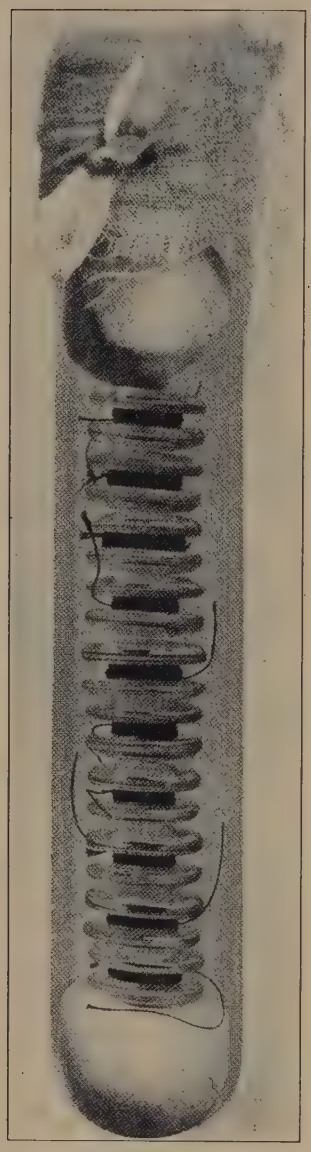
operating on two goitres on the same day, employ catgut for the platysma suture in the one case and very fine silk in the other. There is not only greater local reaction in the cases sewed with catgut but in them the wounds will occasionally open at one or more points to discharge a few drops of clear or cloudy fluid.

Wedded to the use of catgut, the operator develops, undoubtedly, a special technic which enables him to avoid procedures which would be likely to cause trouble or inconvenience, but on the other hand, he is deprived of very useful devices which become indispensable and a delight to the surgeon who has acquainted himself with the possibilities of silk threaded in the ordinary fine straight needle of commerce.

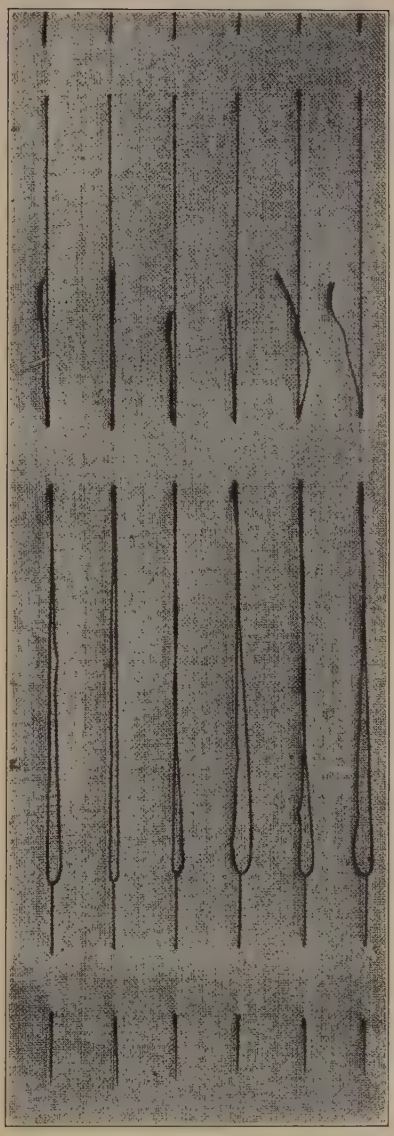
Straight needles of various sizes and lengths are threaded in great number with the silk corresponding in size, and are coarsely basted in rows into strips of thin muslin or gauze (Plate I, 2). The loaded strips are folded and stored for subsequent use. The necessity for threading needles in the course of the operation is thus obviated in great measure. Occasionally more than one hundred of these needles are employed at one operation, since our ligations, for the most part, are made by transfixion of the tissues about the vessel or by piercing the vessel itself when it is large or sufficiently important, or by a combination (Plate II, 2) of these methods. Plate I, 3, illustrates the usual method of controlling haemorrhage from the larger vessels which have been isolated. For the control of bleeding points when the vessels have not been isolated, the needle is passed first under or between the vessel or vessels to be ligated, and then a second transfixion is made, more superficially, close to the point of the clamp and in front of it; the clamp is now tilted in the opposite direction while the operator ties the knot behind it (Plate II, 1). Piercing the tissues a second time in this manner eliminates the trouble of seeing to it that the ligature, in the act of tying, is carried over the tip of the artery clamp. This method enables one also to use to good advantage the forceps with fine points which in my opinion has much to recommend them and which in our clinic are employed almost exclusively, both as clamp and needle-holder.

With the finest silk and needles one can perform feats in haemostasis which would be very difficult or impossible with catgut; for example, the control of small bleeding points over the trachea, of the pia mater, of the periosteum, and the suture of wounds of vessels.

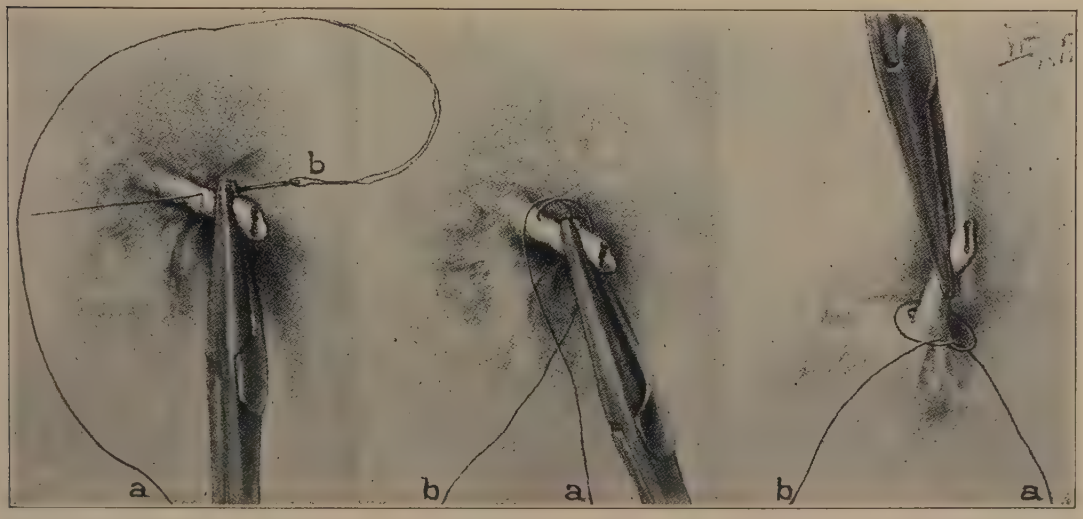
In general terms ligatures taken in this way are drawn only with firmness sufficient to control completely the bleeding, and not so tight as to crush the tissues or interfere unnecessarily with their nutrition. The same tissues tied without transfixion would have to be crushed or strangulated by the ligature and thus, at best, be reduced to the condition of a graft with



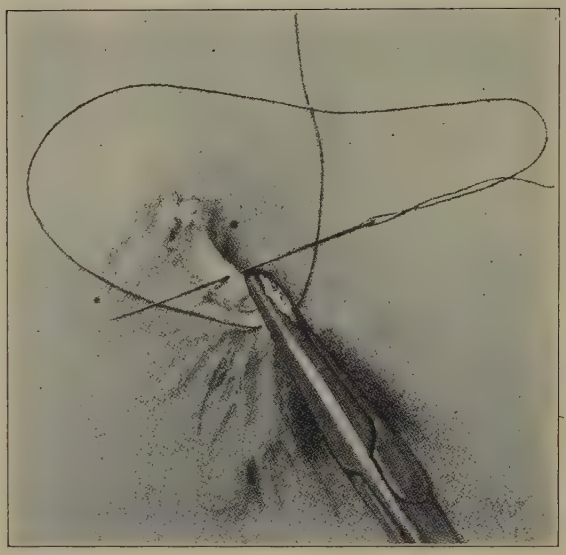
1.—Ligature-spools of glass. A spool is held in the left hand while the right unwinds only so much of the thread as may be required for the ligation of one vessel.



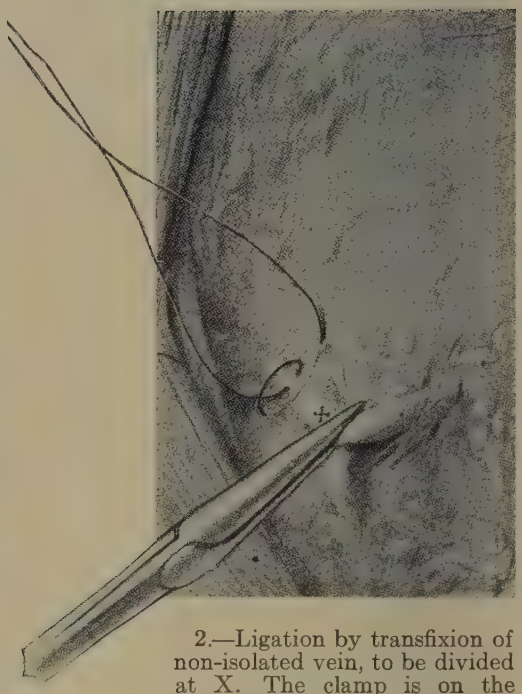
2.—Reduced 3/5. To show method of basting the threaded needles. Silk No. C. Needle No. 9. We usually employ silk two sizes finer than this.



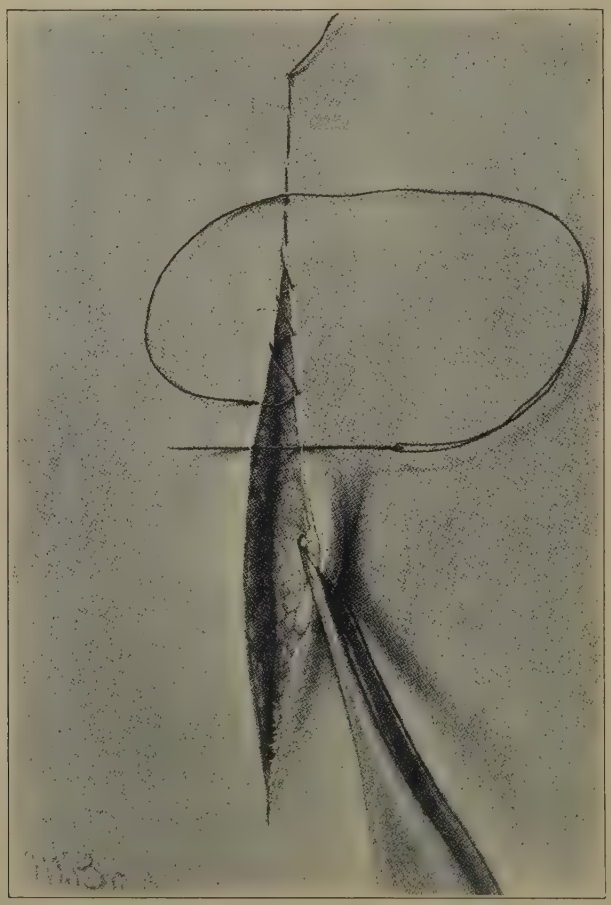
3.—The ligation of an isolated vein or artery by transfixion. The vessel has been twisted to prevent bleeding from the needle-prick.



1.—The usual method of controlling haemorrhage from one or more vessels by transfixion.



2.—Ligation by transfixion of non-isolated vein, to be divided at X. The clamp is on the tumor-side of the vessel.



3.—The epithelial stitch. The thread, needle and bite of skin should be much finer than the drawing indicates.

diminished chances of restitution and with increased danger of wound infection. Furthermore, ligation without transfixion necessitates the use of stronger silk for the reason that a transfixing ligature cannot slip.

The surgeon who has not tested the method will be surprised to find how large a vessel may be safely entrusted to a transfixion-ligature of the very finest silk. I have seen a ligature of coarse silk which had been tied with crushing force, blown off, as it were, from the aorta of a dog—a ligature applied 12 mm. from the proximal end of the divided vessel. This same artery was then safely obturated by a ligature of silk, No. A, which pierced it.

Repeatedly, he who uses catgut finds himself tying with a strand which is coarser than the vessel to be ligated.

Even for long abdominal wounds we rarely use a coarser silk than No. C (Plate I, 2). Occasionally we reinforce with one or two sutures of silver wire which include skin and the anterior and posterior layers of the sheath of the rectus; otherwise fine silk (Nos. AA, A and C), is used throughout for sutures as well as ligatures. We seldom tie *en masse* in the ordinary sense of this term, and in clean wounds, I may say, never.

In the control of haemorrhage, parenchymatous or otherwise, we see to it that the thread is always well buried in the living tissue. It should not bridge over a dead space as a chord subtends an arc. In ligating, for example, the vessels of the superior pole of a thyroid lobe in the course of a lobectomy a fine, short, curved or straight needle, carrying one strand of fine silk is passed behind or between the vessels, and then through the twisted artery, or vein, or both, and the thread is tied on both sides of the clamp. The ligation of the superior thyroid vessels is usually deferred until the end of the operation, these vessels being divided and entrusted to a reliable, fine-pointed clamp in the early stage of the operation.

The difficulty, the cost and the infeasibility of keeping on hand a large supply of needles threaded with catgut, as well as the size of the gut, almost preclude the extensive use of this material for the control of haemorrhage by transfixion.

That surgeons obtained excellent results with silk even when gloves were not worn one may convince himself by the papers of Kocher,[2] Heidenhain[9] and Hägler.[10] Now that rubber gloves are invariably worn, the results with silk, properly employed, are so perfect that I believe its adoption will ultimately become general.

[9] Heidenhain: Centralbl. f. Chir., 1899, No. 26, p. 225.
[10] Hägler: *Ibid.*, 1899, No. 5, p. 132.

A few days ago, seeing a surgeon of eminence and unusual fairness of mind burying sutures of catgut I inquired, "Why do you still employ catgut?"

"Because I cannot free myself of the prejudice against a nonabsorbable suture. I believe," said he, "that it is foolish to use catgut; and every now and then when my wounds break down too frequently I discard it."

The catgut with which he was sewing was No. 2 chromicized; it was guaranteed by America's most reliable firm "not to absorb" for twenty-six days, but not guaranteed "to absorb" within as many weeks.

It should be borne in mind that during the greater part of the period of its disintegration the catgut suture is not only not serving its purpose but is playing the rôle of necrotic tissue, of a culture medium. I trust that I shall not be considered flippant in suggesting that the ideal absorbable suture-material might be a thread which would serve its purpose for, say, ten days and be absorbed in two or three.

Conceded that infection is less likely to occur with silk than with catgut, it would still be objected, and quite pertinently, that, in case it should occur, the buried silk might give endless trouble and have to be removed.

It is well within reason to expect that the technic may be at least so perfect when silk is employed that the wound will become infected not once in a hundred cases. If fine silk were used and the infection slight, probably none of the buried threads would be extruded, nor would healing be delayed demonstrably on account of their presence. When heavy silk has been used for any of the sutures and the suppuration is considerable, one or more or, perhaps, all of the threads would have to be removed. Even in such case it is very unlikely that the ligatures and fine sutures would give trouble.

The Clamp Twist in the Control of the Haemorrhage

A vessel or bleeding point inaccurately caught by the artery clamps and requiring immediate ligation for any reasons may, as is undoubtedly well known, often be controlled by a half-twist or slight rotation of the clamp. The precise situation of the vessel may then be determined by cautiously untwisting the instrument to the degree necessary to permit the escape of a fraction of a drop of blood and then retwisting. Now, instead of removing the clamp and trying again to catch the vessel in a field which might be more or less obscured by haemorrhage, one transfixes in a dry field at the proper place and ties on one or both sides of the forceps; or if there is indication and room for two clamps, a second may be applied when the exact situation of the bleeding point has been revealed by the untwisting of the first.

The surgeon can transfix accurately with one hand while he holds the clamp in the other, and, by pulling on the twice transfixing thread, check the haemorrhage before tying. The bleeding being arrested, both hands are free for making the knot.

The Interrupted Stitch

We find ourselves using the interrupted variety of suture even more frequently than formerly. It is more accurate, reliable and convenient than the running stitch, and, with the long straight needles armed and conveniently arranged as I have described, can be taken about as quickly as the latter. The head nurse of the operating-room hands the threaded needles to the surgeon, presenting them to him pointward. The operator can take a stitch in the time required by the nurse to withdraw the next needle and thread from the cloth in which they have been basted. The knots are tied after all the stitches have been taken. With the aid of a good assistant very little time is consumed in the tying. A granny knot is adequate when fine silk is used. In some instances the granny is better than the reef knot, for in the tying of the former in the presence of tension the traction on the first turn of the knot can easily be maintained, and should the first turn loosen, in the taking of the second the slack can usually be taken up in the drawing home of the latter.

Undrained Wounds

Fine silk frequently enables one to close a wound which would have to be drained if catgut were employed. Bleeding points so fine as to be awkwardly or not at all ligable with catgut may be readily and quickly controlled by a transfixing suture of the finest silk tied sometimes with merely a half knot. When the ends of such a knot are cut very short the silk is barely visible.

I am taking for granted it will be conceded that unless the haemostasis is quite perfect and the likelihood of bleeding after closure of the wound negligible, drainage should usually be resorted to. Unfortunately catgut as material for ligature does not afford the security from haemorrhage that silk does, partly because its knots are not so dependable and partly because, as I have said, the former cannot so conveniently or so universally be resorted to for transfixion as the latter.

Faulty Technic

The surgeon who desires to use silk and who, after giving it a fair trial, finds that his results are not so good as with catgut may, I think, quite

surely attribute his failure to himself—to faulty technic. By faulty technic I do not mean merely breaks in asepsis.

One should not of course use silk for ligating or suturing in the presence of infection. Nor should one bring parts together under such degree of tension as to cause necrosis or interfere greatly with the blood-supply, for nothing is gained by so doing and decided harm may result. Healing is menaced when the circulation of the tissues to be united is impaired.[11]

In operations made through healing tissues catgut may occasionally be used in preference to silk.

The silk employed should never be coarser than necessary and it is well to employ for suture a thread which is not stronger than the tissue itself. A greater number of fine stitches is better, as a rule, than a few coarse ones.

Avoid, if possible, the combined use of silk and catgut in a wound.

For sewing up an abdominal wound, when it is necessary here and there to take heavy deep stitches perforating skin and muscles, silver wire serves admirably. When the skin can be approximated without tension we usually employ interrupted perforating stitches of very fine silk. If the skin-edges have to be brought together under considerable tension we recommend a subcuticular stitch of silver wire taken with the Hagedorn or Schnitzer[12] needle.

I have presented this matter in such detail because so many have tried with indifferent or worse than indifferent success to substitute silk for catgut, and because I am told, as I have said, that the operators and pupils of the surgical clinic of The Johns Hopkins University are quite the only ones in this country who systematically employ the former.

I believe that the tendency will always be in the direction of exercising greater care and refinement in operating, and that the surgeon will develop increasingly a respect for tissues, a sense which recoils from inflicting unnecessary insult to structures concerned in the process of repair.

The Epithelial Stitch

In the toilet of wounds in animals we meet conditions different in some respects from those which obtain in the human subject. The long hair, the deep follicles of the skin of dogs and the inconveniences incident to sub-

[11] In operations for the oblique as well as the direct form of inguinal hernia we sometimes split vertically the sheath of the rectus muscle for the relief of strain on the stitches holding together the internal oblique muscle or conjoined tendon and Poupart's ligament.

[12] It is known only to a few surgeons that the late Dr. Schnitzer, surgeon to the German Hospital, New York, devised and used the needle curved on the edge some years before Hagedorn described it.

sequent dressings make it desirable to modify the technic of closing the wounds in these animals.

Stitching of the platysma muscle does not hold together sufficiently well the edges of the skin, and the subcuticular stitch taken close to the incised border is not so safe in the dog as in the human subject because the follicles are relatively deeper and more numerous in the former. Hence, in the dog, after suturing the platysma we place a running subcuticular suture a little further than usual from the free edge of the skin. Should now the approximation of the skin not be sufficiently perfect we add the "epithelial stitch." This is made with silk about 00 fine and with a needle to correspond. Hardly more than the epithelium is pierced by the needle, and the suture when completed describes almost a straight line (Plate II, 3). The epithelial stitch produces no irritation and does not require subsequent attention, for it rubs off in the ordinary process of attrition, or it may be pulled off at any time like a plaster. Inasmuch as, in dogs, stitches which pierce the skin should be removed in two or three days lest the infection which they cause give rise to suppuration, and as it is undesirable and troublesome in the case of animals to remove stitches or to expose the wound so soon after operation, stitching in some such way as above described has decided advantages.

Celloidin-Batiste

In many of our operations, and always when it seems particularly indicated, we paste to the skin over a wide field a fine batiste (sometimes gauze, or silk) dipped in celloidin.

In amputations at or near the hip-joint, the actual field of operation may or may not be covered with the cambric. A liberal flounce-like sheet pasted along the side of the genitals from pubes to sacrum, along Poupart's ligament and from the anterior superior spine of the ilium along the outer side of the thigh to the tuberosity of the ischium, in other words a truncated hollow cone which encircles the thigh just above the line of amputation, suffices. This flounce should extend well up on to the abdomen and back and side, and down on the inside of the opposite thigh.

Gloves

Rubber gloves must, of course, be worn by all concerned in the operation.

In a letter of a few weeks ago the director of a famous German clinic asked me to give him references to articles that I might have written on the subject of rubber gloves. As response to his request and believing that a brief account concerning the introduction of gloves may eventually be of interest I will, in as few words as possible, relate the story.

In the winter of 1889 and 1890—I cannot recall the month—the nurse in charge of my operating-room complained that the solutions of mercuric chlorid produced a dermatitis of her arms and hands. As she was an unusually efficient woman, I gave the matter my consideration and one day in New York requested the Goodyear Rubber Company to make as an experiment two pair of thin rubber gloves with gauntlets. On trial these proved to be so satisfactory that additional gloves were ordered. In the autumn, on my return to town, the assistant who passed the instruments and threaded the needles was also provided with rubber gloves to wear at the operations. At first the operator wore them only when exploratory incisions into joints were made. After a time the assistants became so accustomed to working in gloves that they also wore them as operators and would remark that they seemed to be less expert with the bare hands than with the gloved hands.

I think it was Dr. Bloodgood, my house surgeon, who first made this comment and that he was the first to wear them, *invariably,* when operating.

In the report[13] which I made of the first year's work at the hospital, written in November and December, 1890, and published in March, 1891, I stated that the assistant who passed the instruments wore rubber gloves. This assistant was given the gloves to protect his hands from the solution of phenol (carbolic acid) in which the instruments were submerged rather than to eliminate him as a source of infection. I do not recall having referred again, in my publications, to the employment of rubber gloves. Dr. Hunter Robb in 1894, in his book on aseptic technic[14] recommended that the operator wear rubber gloves. Dr. Robb was, at that time, resident gynaecologist of The Johns Hopkins Hospital and had frequent opportunities to observe the technic of the surgical clinic.

This incidental reference by Robb in 1894 to the wearing of rubber gloves, and the fact that a photograph of an operation for breast cancer taken late in the year 1893 shows that gloves were not being regularly worn by us at that time, serve to establish approximately the date of their definite introduction.

Dr. Joseph C. Bloodgood, in his elaborate report[15] on Hernia makes the following statements with reference to the wearing of gloves:

"The writer was the first as operator to wear gloves as a routine practice in practically all clean operations. He began to wear gloves invariably in December, 1896; before this date he had operated in twenty cases of hernia

[13] Johns Hopkins Hosp. Rep., iv, No. 6, plate xii.

[14] Robb, Hunter: Aseptic Surgical Technic.

[15] Johns Hopkins Hosp. Rep., Balt., 1889, vii. Operations on 459 cases of hernia in The Johns Hopkins Hospital from June, 1889, to January, 1899.

with four suppurations, all late infections; wounds were closed with silver wire. Since wearing gloves he has operated in 100 cases of inguinal hernia. In one case (recent) the wound suppurated.

"Rubber gloves were introduced by Professor Halsted soon after the hospital opened in 1889. They were invariably worn by the assistant who handed instruments and by the assistant at the wound, usually the nurse in charge of the operating-room. The operator himself rarely wore gloves (*at that time*)[16] except when clean joints were opened."

Thus the operating in gloves was an evolution rather than an inspiration or happy thought, and it is remarkable that during the four or five years when as operator I wore them only occasionally, we could have been so blind as not to have perceived the necessity for wearing them invariably at the operating-table.

It is also noteworthy that none of the many surgeons, foreign and American, who visited our clinic in those years should have recognized the desirability of eliminating the hands as a source of infection, by the wearing of gloves.

We did not realize how slightly the sense of touch is obtunded by the rubber covering,[17] or how unessential it is in most operations that the greatest delicacy of finger perception be preserved. Furthermore we were delighted with the results in healing already obtainable, so vivid were the memories of infections in the recent past.

Silver Foil

Since 1894[18] we have covered our fresh wounds with silver foil and are quite convinced that this dressing has appreciable chemical as well as physical values.

That various metals inhibit the growth of certain organisms had been proved by Miller,[19] Nägeli,[20] Behring,[21] Uffelman,[22] Meade Bolton[23] and others.

[16] Italicized words mine.

[17] For example, in the early days of rubber gloves I removed the glove from one hand, not infrequently, to palpate the common bile-duct in search for stone.

[18] Halsted: Am. Jour. Med. Sc., July, 1895.

[19] Miller: Demonstration einer Methode zur Bestimmung der antiseptischen Eigenschaften von Zahnfüllungsmitteln, Verhandl. d. deutsch. odont. Gesellsch., 1889, i, 34.

[20] Nägeli, C. von: Ueber oligodynamische Erscheinungen in lebenden Zellen. Denkschr. d. schweiz. naturforsch. Gesellsch., 1893, xxxiii, 1. See also review in Bot. Centralbl., lv, 93.

[21] Behring: Ztschr. f. Hyg., 1890, ix, 482.

[22] Uffelman: Beiträge zur Biologie des Cholerabacillus, Berl. klin. Wchnschr., 1892, No. 48, p. 1212.

[23] Tr. Assn. Am. Phys., 1894, p. 174.

Bolton's work interested me particularly because very kindly, in our behalf, he tested thoroughly the effect of silver on the growth of the common pyogenic microorganisms. For his experiments he used silver in various forms but particularly the silver foil with which we were at the time covering our wounds.

I had previously employed foils of copper, brass, gold and aluminum and had found that copper and brass irritated the skin. The silver foil had given, clinically, the most satisfactory results and I was pleased to find that its use had the support of Bolton's carefully conducted experiments. The admirable behavior of wire in wounds which has been commented on for centuries may, therefore, be attributed to its antiseptic properties.

Under the foil the stitches which perforate the skin may, it seems to me, be left undisturbed for a greater number of days than under the ordinary dressings. Thiersch grafts implanted on clean fresh surfaces and covered with silver foil need not be investigated for ten days or more. The foil, while it seals the dry wound hermetically, readily permits the escape of fluids.

We may, possibly, overestimate the value of silver foil as a dressing, but we are wedded to its use, and I know of nothing which could quite take its place, nor have I known any one to abandon it who had thoroughly familiarized himself with the technic of its employment. Moistening the skin and the applied foil with alcohol facilitates its application, but alcohol should not be employed in the laying on of the foil over skin-grafts.

Three or four layers of foil are usually placed on the closed incision, and over these is laid the thin paper between the leaves of which the foil is packed. We have occasionally covered the foil with strips of very thin, bibulous, Japanese paper. Foil without paper and covered with crêpe lisse and celloidin makes a particularly neat dressing for wounds of the face and scalp.

Gutta-Percha Tissue

Dr. Jacob Frank,[24] in an interesting account of the discovery of gutta-percha and the uses of gutta-percha tissue in surgery stated that perhaps the first mention of this tissue is to be found appended to a report on gutta-percha submitted to the Académie de médecine, July 30, 1850, by a commission composed of Messrs. Chevallier, Poiseuille and Robert. Consulting this report, I find that it was called *tissu électro-magnétique,* approved by the National Academy of Medicine, tested in the various hospitals in Paris, and recommended as a sovereign remedy for gout, rheumatism, sciatica,

[24] Frank, Jacob: Gutta-Percha Tissue in Surgery, The Journal A. M. A., March 19, 1910, p. 942.

migraines, neuralgias and gastralgias, for the resolution of varices, for the dressing of wounds, burns, etc.; also for pneumonia in its early stages. The tissue was relatively thick; it could be washed and used indefinitely, and was represented as being greatly superior to the medicated oiled papers which were not only inert but soiled the body and the linen and were altogether disagreeable in use. "To convince oneself of its magnetic properties, one had merely to rub it lightly on a piece of cloth and hold it above sawdust. Instantly particles of the sawdust would spring up and attach themselves to the tissue."

In the light of our experience with the gutta-percha tissue of the present day we can well believe that the *tissu électro-magnétique* was really serviceable at times in the treatment of the affections enumerated. Its disuse may have been due in part to its pseudonym.

Dr. Manoury,[25] six years later, recommended medicated plaques[26] of gutta-percha.

"To apply a plaque one dips it in warm water, 40 degrees, in order that it may conform by its flexibility to the protuberances and anfractuosities of the ulcer; when it has been applied one covers it with a cloth wet with cold water, with view to preventing the adhesions of this cloth to the external surface of the plaque."

A. Cousin[27] in 1872 wrote as follows:

"Gutta-percha, on account of its numerous and valuable properties, has for a long time attracted the attention of practitioners of medicine and surgery, and on consulting the instructive collection of the *Bulletin de thérapeutique* one finds not less than twenty-three papers devoted to the consideration of the diverse uses of this substance.

"It has been employed, in the solid state, in the fabrication of apparatus for fractures, of caustic pastes, of sounds and bougies, of protheses, of various utensils; dissolved in chloroform it was at one time much vaunted in the topical treatment of certain skin affections as substitute for collodion.

"Every one knows today the excellent results obtained by the occlusive method in the treatment of a great number of medical and surgical affections (occlusive dressings, compressing or contracting, of collodion, swathing in impermeable cloths, pneumatic occlusion, wadded splints, etc.). It would take too long to study, comparatively, the indications for the various dressings or the advantages and defects that they present; I wish simply to

[25] Manoury, A.: Des plaques de gutta-percha médicamenteuses et leur applications, Bull. gén. de therap. méd. et chir., 1856, vol. l.

[26] *a*. Plaques de gutta-percha et de limaille de fer porphyriseé. *b*. Plaques vésicantes composés de gutta-percha et de cantharides. *c*. Caustique fluidifiant (gutta-percha and potassium). *d*. Caustique coagulant (gutta-percha and chlorid of zinc).

[27] Cousin, A.: Sur l'emploi de la gutta-percha laminée comme agent d'occlusion, Bull. gén. de therap. méd. et chir., 1872, lxxxii.

make known to the readers of the *Bulletin* a method which I believe to be new and which is assuredly a simple and easy one for making occlusion.

"I employ for this purpose leaves of gutta-percha reduced by rolling to the thinness of waxed taffeta, and I take advantage of its extreme solubility in chloroform to give to this material adhesive qualities of considerable degree.

"I proceed in the following manner: Given a surface of skin to be covered, I cut a piece of flattened gutta-percha to dimensions two or three times as large as this area; I trace along the border of this variety of plaster, for an extent of 1 or 2 cm., a brush dipped in chloroform and apply it immediately to the skin; adhesion takes place with great energy at all the points touched by the chloroform, and so perfectly that the slightest irregularities of the skin are reproduced with remarkable fidelity in the impermeable material."

I have quoted at such length from the article of Dr. Cousin in order to make clear what were the uses which had been made of gutta-percha tissue to the year 1872, and because it may be interesting to others to read the original description of a clever and useful procedure—the pasting of the edges of a leaf of gutta-percha to the skin by means of chloroform.

Occasionally we paste with chloroform a small scrap of gutta-percha tissue to a piece of old linen when the skin surrounding the granulating surface which is to be covered with gutta-percha tissue is likely to become irritated by the discharges from the ulcer. In such case the protective is cut to the precise size of sore, the skin about which being covered with an ointment of zinc oxid; the discharges are promptly absorbed by the linen and overlaid dressings. It is well, under these conditions, to cut a tiny hole through both protective and linen to permit the prompt escape of the secretions of the wound into the dressing.

Dr. Frank gave two references [25, 27] to the early employment by physicians of plaques or "sheets" of gutta-percha, but was unable to make any statement relative to its introduction in its present form and for its present purposes, and leaves unfilled a gap of perhaps a quarter of a century.

As I know of no one except myself who can tell the story, I may be pardoned for a moment's indulgence in reminiscence.

As interne of Bellevue Hospital, New York, from 1876 to 1878 I had frequent opportunities to observe the pain and bleeding incident to the tearing out of gauze from large involucral cavities after sequestrotomy—gauze which had been stuffed into these cavities to arrest bleeding and into which the granulations had grown, often for a considerable distance. Wounds of the soft parts would also be packed with gauze, which from its adhesion to the skin would cause pain, sometimes very distressing, and the first removal of the gauze was an event anticipated with apprehension by

the patients, who were quite sure to be advised by their ward-neighbors of its terrors.

During the two years of my study abroad the desirability of obviating this rather barbarous practice was repeatedly enforced on me by what I saw in the foreign clinics, and on my return to America in 1880 I promptly cast about for some sort of protective, non-adhering dressing. Oiled silk and the green protective of Lister were not sufficiently pliable. Finally a salesman in one of the surgical supply stores showed me a bed-sheet of gutta-percha as heavy as blotting-paper, remarking that it could be rolled out to any degree of thinness. I requested him to procure the thinnest tissue possible, and in the course of a few weeks he provided me with samples, none of which was sufficiently thin. After a month or two tissue of the desired thinness was obtained and from that day until the present, a period of nearly thirty-three years, gutta-percha tissue, usually referred to as rubber tissue or protective, has been one of the most prized and indispensable articles of my surgical armamentarium.[28]

Accounts of the first employment of gutta-percha tissue to protect granulations from insult and to prevent them from growing into or adhering to drains, gauze packs and dressings and to promote healing under a moist scab can probably be found in the records of the Roosevelt Hospital Dispensary, New York, from 1881 to 1886, the term of my incumbency as director of this dispensary; and some of my assistants and students of those years will doubtless recall having employed it there as a dressing for wounds.

I have not searched for references to the use of gutta-percha tissue in its present form and for its present purposes subsequent to the time of its introduction in 1881, but I am quite sure that no mention of it will be found prior to 1884 or 1885, and that should there be any such it will have been made by surgeons of New York who might have learned of it from my students or seen it employed at one of the various hospitals with which, as attending surgeon, I was connected.

Its employment as drainage material for the abdominal cavity came about as follows:

At first we tucked it about the gauze drains at the surface only, in order to prevent adhesions to the skin. Then the protective was carried deeper and deeper into the wounds until finally the entire gauze drain or gauze pack, except at the very bottom, was enveloped in the gutta-percha tissue.

The experiments of Dr. Yates of my staff, made to determine the amount of time required for the formation about the protective of intestinal adhesions, were especially important and had their influence in emboldening

[28] Brief reference to the use of gutta-percha tissue is made in Johns Hopkins Hosp. Rep., ii, No. 5, p. 306.

the surgeon at times to dispense altogether with the gauze, placing his reliance on the gutta-percha.

Not very often do we venture to drain an abdominal wound with nothing but protective. Usually the cigarette form of drain is employed—gauze enveloped in protective—when we wish to know that a drain is precisely and promptly fixed in the desired position, as it is by the little tuft of gauze at the bottom of the cigarette.

For certain cases in which it seems desirable that adhesions should form more rapidly and firmly about the abdominal drain we make it as follows: Two squares, one of gauze (single sheet) and one of protective, are rolled together, the gauze outside, until a drain of the desired thickness is obtained. Granulations cannot pierce this drain deeper than the single layer of gauze, because they at once encounter the underlying protective. Such a drain is removed quite as easily as the cigarette drain and offers a little more security than the latter.

A moist scab, so-called, is better than a dry one. The surgeon has many opportunities to convince himself of this. When he has occasion to extract a toe-nail let him cover one-third of the raw surface with protective and allow the remainder to heal under the dry scab. The patient may have pain in the digit soon after the dry scab is well formed, and the surgeon will perhaps observe that the soft parts about the nail-bed on the side of the dry scab are inflamed. On covering the entire surface of the granulating wound with gutta-percha tissue the pain will promptly be relieved and the inflammation subside.

The dry scab imprisons secretion which in turn gives rise to tension, and the tension impairs the vitality of the tissues under and at the border of the dry scab to an extent sufficient to place them at a disadvantage in their combat with the microorganisms, and to compel absorption of the toxins.

Even pimples and trivial wounds of, for example, the fingers behave best under the moist scab. For the healing of wounds under the moist blood-clot, particularly when the skin cannot be made to cover the cavity to be filled with blood, gutta-percha tissue is invaluable. It would be found useful in every household and should be included in the supplies provided for first aid to the injured. The value of the moist scab should be common knowledge for the layman, and gutta-percha tissue should replace for him the sticking-plaster as a covering for wounds.

A few months ago in reading one of Lister's[20] first papers on the use of phenol in wounds I noted that he mentions having covered a wound with a tissue of gutta-percha. This interested me so much that I wrote at once to Sir William Watson Cheyne, being confident that no one could give me

[20] Lancet, London, March 16, 1867, p. 328.

the desired information so well as he. From his kind reply I quote as follows:

"So far as I understand the matter, Lister tried various materials to cover the wound after an operation, so as to prevent the phenol in the dressing from penetrating in any quantity to the wound. Among other things he tried gutta-percha tissue, but he abandoned that because the phenol easily passed through it so that it did not protect the wound from the irritation of the antiseptic, and the material he ultimately hit on was oiled silk, covered with a layer of dextrin, so as to allow it to be wet. The oiled silk itself did not prevent the phenol vapor from passing through it, but the combination of oiled silk and shellac, according to Lister's experiments, did. As regards any question of priority in using it, so far as any claim can be advanced on Lister's behalf, it would not hold, because he tried it and abandoned it as being unsuitable for his particular purpose."

From 1879 to 1889 I made frequent visits to England and the continent and was in close touch with the work of the surgical clinics of England, France and Germany, and not once in that period did I see gutta-percha tissue employed in Europe.

It is gratifying to me to observe the place in surgery which gutta-percha tissue has gradually won for itself. For the American surgeon it has become an indispensable appurtenance of his equipment.

ASEPTIC SURGERY IN NEW YORK IN 1884[1]

Dr. William S. Halsted thought that it would be difficult in a given case to know just what to attribute a bad result to, with the imperfect antiseptic technic at present existing even in our best New York hospitals. Trained nurses, with long sleeves and hands uninspected, were allowed to pass and hold dry sponges. He had repeatedly observed ligatures handed to the operator from the mouth of the interne, and seldom failed to find instruments, especially artery clamps, which had been insufficiently cleaned. He observed further that in some of the hospitals the preparation of the catgut was intrusted to the apothecary, and, even if it was prepared by the interne it would not be a guarantee that it was properly, even if conscientiously, done.

[1] Remarks in discussion of Dr. Thomas M. Markoe's paper. "Recurring carcinoma of the arm; capillary drainage." New York Surgical Society, October 14, 1884. (These brief remarks are included because of their historical interest.—Editor.)
N. York M. J., 1884, xl, 497.
Also: Med. News, Phila., 1884, xlv, 495.

INCISION FOR NEPHRECTOMY[1]

Dr. W. S. Halsted thought that, irrespective of the question of comparative risk, most surgeons would allow that neoplasms of the kidney could be more satisfactorily dealt with through the abdominal incision. Certain operators, who were complete masters of the technic of abdominal surgery, would be justified in preferring and practising laparotomy in the removal of kidney tumors, whereas the great majority of surgeons might prefer, for the present, to confine themselves to the lumbar incision. Each surgeon should, therefore, be the conscientious judge of his own attitude. Thus it was easy to comprehend why von Bergmann, Thornton, Tait, and others should adopt the abdominal incision; and, although Tait would not confess the secret of his success, it was quite apparent to others that it was to be ascribed to operative skill and most careful asepsis.

Dr. Halsted was inclined to advocate, for the abdominal incision, a line lateral to that recommended by Langenbeck, for two reasons: first, to avoid, if possible, subsequent hernia, and, second, to enable one, early in the operation, to sew off the operative field from the general peritonaeal cavity. It seemed to him that the suggestion from Hagen-Torn ("Centralbl. für Chir.," No. 35, 1884) to cut through the rectus abdominus muscle rather than through the linea alba, to prevent hernia after ovariotomy, was a good one. He advised also that especial attention should be paid to the sewing of the incision through the oblique and transverse abdominal muscles. A cross-cut of such a wound would give two lines, irregularly concavo-convex, demonstrating that the various tissues had retracted unequally, and that, to make the cut surfaces offer the broadest possible face, it would be necessary to convert the undulating into plane surfaces. This could be done by one or more rows of buried sutures aimed at the concavities. To enable one to operate outside of the peritonaeal cavity, Dr. Halsted recommended a procedure to which he had resorted in his case. The abdominal cavity was opened along Langenbeck's line. In future cases he would open it outside of this line, as just described. In front of the carcinomatous kidney was the descending colon. The parietal peritonaeum was a second time divided at about three inches from the outer border of the colon and

[1] Remarks in discussion of Dr. Robert F. Weir's paper, "Extirpation of the kidney." New York Surgical Society, December 9, 1884.

N. York M. J., 1884, xl, 734.

Also: Med. News, Phila., 1885, xlvi, 15.

the kidney readily removed. The haemorrhage from the kidney-bed was rather profuse from, perhaps, about a hundred oozing points. This was only partially controlled by about as many catgut ligatures. The peritonaeal cavity was then closed off from the field of operation by uniting the mesial edges of the twice-divided peritonaeum.[2] Thus an extraperitoneal cavity was formed, bounded postero-externally by the kidney-bed and the abdominal paries which had been robbed of its peritonaeum; antero-externally by the isolated strip of peritonaeum, the margins of which were the lateral edges of the original parietal incisions; and internally by the outer surface of the somewhat curtailed peritonaeal cavity. The extraperitonaeal cavity was drained (anteriorly) by two large rubber tubes. The haemorrhage stopped at once from intestinal pressure and convinced the operator that he might have spared himself much trouble and the patient some shock, if, instead of applying so many ligatures, he had earlier closed off the peritonaeal cavity as described. The patient recovered rapidly from the shock of the operation and passed a comfortable night. In the morning he developed uraemic convulsions, which recurred at intervals until his death, about twenty-seven hours after the operation. He secreted, in this time, only an ounce and a half of urine.

A complete autopsy was not allowed. Injection of the extraperitonaeal cavity demonstrated that the peritonaeal cavity had been completely shut off. In the latter was about a drachm of slightly stained serum, but there were no other evidences of peritonitis. Microscopical examination revealed advanced interstitial disease of the right kidney. Dr. Halsted thought it fair to attribute the convulsions to the condition of the right kidney, for the patient's pulse was too strong to make it probable that diminished blood-pressure alone might have been the cause of the oliguria.

[2] An original procedure.—W. S. H.

A NEEDLE-HOLDER FOR HAGEDORN'S NEEDLES[1]

Of the very many surgeons who use the so-called Hagedorn's needles, there are probably not a few who do not understand the peculiar advantages of them. I am quite sure of this because of the popularity of a certain holder which defeats the very object of the needle which it is designed to hold.

The ordinarily strongly curved needles—needles curved on the flat—must be grasped by the needle-holder in such a way that one jaw of the holder presses the concave side of the needle at two points and the other jaw presses the convex side of the needle at an intermediate point. If it be necessary to exercise much pressure the needle grasped in this way may readily be broken.

Inasmuch as strongly curved needles are used as a rule only for the application of more or less difficult stitches—of stitches in the deeper recesses of wounds—the breaking of such a needle just before the completion of a stitch may be very annoying.

Hagedorn's needles are curved on the edge and flattened on the sides. They cannot, except with great force, be broken by a holder which grasps them properly—which grasps their straight, flat sides.

New holders for Hagedorn's needles are devised almost every year. One of the holders, the most popular one perhaps in the country, was devised about six years ago by a New York practitioner. It grasps the needles by their curved edges and thus exposes the needles to the very danger which they were devised to prevent.

Twenty years or more before Dr. Hagedorn described his needles it had occurred to Dr. Joseph Schnötter, attending surgeon to the German Hospital, New York, to devise not only needles precisely like the so-called Hagedorn needles but also a needle-holder essentially the same as that which Dr. Hagedorn regards as his improved needle-holder.

A few years ago I saw Dr. Schnötter's original needle-holder among the instruments of the German Hospital, and was informed that it had seldom been used by any one except the inventor.

[1] Brief remarks in discussion of Dr. J. Whitridge Williams' demonstration, "A new needle-holder." The Johns Hopkins Hospital Medical Society, Baltimore, February 2, 1891.

Johns Hopkins Hosp. Bull., Balt., 1891, ii, 63.

THE INTRODUCTION OF "GUT-WOOL"

AND A REVIEW OF THE BOOK

"ANLEITUNG ZUR ASEPTISCHEN WUNDBEHANDLUNG"[1]

This little book cannot fail to do good, and we commend it to every practitioner and student of surgery. The author considers his subject under the following heads:

1. The significance of the aseptic treatment of wounds.
2. Air and contact infection.
3. The causes of wound infection.
4. Disinfectants.
5. Disinfection of the surface of the body.
6. Sterilization of metal instruments.
7. Aseptic dressings.
8. Aseptic sutures and ligatures.
9. Aseptic wound drainage.
10. Aseptic materials for sponges.
11. Aseptic injection and puncture.
12. Aseptic employment of catheters and bougies.
13. Fluids for cleansing and irrigation.
14. Wards and operating rooms.
15. Aseptic operations and wound treatment.
16. Aseptic emergency dressings and the treatment of injuries.
17. Bibliography.

One would not expect to find much that is new in such a book as this; but in chapter 6 which treats of the sterilization of metal instruments the author advocates a method which originated with him and which he described about nine months ago in Langenbeck's Archives. The instruments are boiled for five minutes or less in a 1 per cent solution of washing soda. The soda prevents the rusting of the instruments and increases very much the sterilizing power of hot water.

Behring discovered to his astonishment that the ordinary soda lye of the laundry at a temperature of 85° C. killed anthrax spores often in four

[1] A review of the book, "Anleitung zur aseptischen Wundbehandlung" by Dr. C. Schimmelbusch, and remarks on the introduction of "gut-wool."
Johns Hopkins Hosp. Bull., Balt., 1892, iii, 63-64.

minutes and always in eight or ten minutes. The usual concentration of the washing lye is 1.4 per cent.

In the author's experiments staphylococci and *Bacillus pyocyaneus* were killed in the boiling 1 per cent soda solution in two to three seconds, and anthrax spores which in several instances had resisted steam at 100° C. were killed in two minutes. A dipping of the instruments for several seconds would, according to S., suffice to kill the pyogenic organisms, and a boiling for five minutes in the soda solution should satisfy all the claims of ordinary practice.

Rapidity and certainty of germ destruction are not the only advantages of the author's method. Of great worth is the simplicity of its accomplishment. One requires nothing more than may be found in any household—fire, water, washing soda and a vessel.

The author has devised for v. Bergmann's Klinik an apparatus in which to boil the instruments. It provides for rapid heating of the water and convenient transfer of the instruments. Illustrations, though not very good, facilitate the description of the apparatus. The instruments having been sterilized are transferred to trays containing carbol-soda solution (aa 1 per cent) or preferably to a boiled soda solution (1 per cent).

Accepting Schimmelbusch and Behring's experimental results we have boiled our instruments in the 1 per cent soda solution ever since the publication of Schimmelbusch's article about nine months ago. This method has a disadvantage which Schimmelbusch does not mention. The instruments are so slippery when removed from the soda solution that, for us at least, it is practically impossible to work with them. We have been obliged, therefore, to discard the use of the carbol-soda solution (aa 1 per cent) for the instrument trays, and return to the carbolic acid solution (1-30). The instruments having been boiled in the 1 per cent soda solution are thoroughly rinsed in 1-30 solution of carbolic acid before being placed in the instrument trays.

In chapter 7, page 104, Schimmelbusch informs his readers that catgut is made from the sheep's intestine and not, as the name would indicate, from the intestine of the cat. He describes the manufacture of catgut as follows:

"In accordance with Lister's directions, the small intestine of the sheep is freed of its mesentery, washed in water, and then manipulated upon a board with an instrument like the back of a knife. As the blunt instrument is drawn with a scraping motion over the intestine the so-called 'dirt' is removed; this is nothing else than the mucous membrane of the intestine. In like manner the circular muscular coat is rubbed off, so that only the very thin tube constituted by the longitudinal coat remains, which may be inflated so as to represent a well preserved delicate tube-like structure.

From this the threads are manufactured by twisting, and, according to the thickness desired, either the entire tube or strips of the same are employed."

To suppose catgut to be made from the longitudinal muscular coat of the intestine might be an excusable error if a knowledge of the gross anatomy of the wall of the intestine were not indispensable to every surgeon. To attempt, for instance, a circular suture of the intestine without any knowledge whatever of the coats of the intestine is, to say the least, not right. No one familiar with the coats of the intestine would for a moment accept the suggestion that catgut is made from the longitudinal muscular coat, or believe that this coat could be so dissected as to represent a perfect tube which might be distended with air. Catgut is made from the submucosa and not from the longitudinal muscular coat. The submucosa [2] is the most important coat of the intestine for the surgeon. Without it a circular suture of the intestine would be an almost certainly fatal operation.[3] The submucosa may be readily disengaged from the other coats of the intestine by simply engaging the intestine firmly between the handles of a scissors and pulling the intestine. The handles allow nothing but the submucous coat to pass between them. The serous and muscular coats become stripped off from the outer side and the mucous coat from the inner side of the intestine. The submucosa may then be inflated and dried. *From the submucosa obtained in this way we have made what we call gut-wool.*[4] We use this gut-wool solely for the purpose of stopping excessive haemorrhage from bone. To manufacture the gut-wool the dried submucosa is moistened with absolute alcohol and cut into fine shreds with a tobacco-cutting machine. The wool is then preserved in an alcoholic solution of corrosive sublimate (1-1000). To plug bone sutures or bleeding points in bone take a very small quantity of the wool in a sharp-pointed forceps and press it into the bone. We have found this to be an instantaneous and infallible method of arresting haemorrhage in bone.

Chapter 15, on aseptic operating and the aseptic treatment of wounds, disappoints us. Schimmelbusch entertains v. Bergmann's great dread of blood in wounds, and upholds the assertion made ten years ago by the latter, that no surgeon should look for good results who does not with the

[2] Halsted: Circular Suture of the Intestine. American Journal of Medical Sciences, October, 1887. Halsted: Intestinal Anastomosis. Johns Hopkins Hospital Bulletin, No. 10, January, 1891.

[3] Kummer's operation (*vid.* Archiv für klin. Chirurgie, 1891, Bd. xlii, Heft 4), is a badly conceived one. I have tested it four times on dogs. All of the dogs died sooner or later from perforation. The muscular "cuffs" unsupported by the submucosa expand into the thinnest conceivable film and finally rupture.

[4] An original contribution by Dr. Halsted.—Editor.

greatest care stop every bleeding point. Our work alone,[5] clinical and experimental, has taught us not to fear a dead space occupied, without tension, by a blood clot more than an obliterated dead space whose walls, constricted by obliteration sutures, are studded with ligatures and little areas of strangulated tissues. The rapidity with which granulation tissue fills a dead space is marvelous, provided the circulation of the walls of the dead space be vigorous and has not been interfered with by ligatures or sutures. A cavity as large as an English walnut in the cancellous tissue of bone, for example, may become completely filled with granulation tissue in forty-eight hours. Whether antiseptic precautions be employed or not, the blood clots, occupying freshly made dead spaces, become, as a rule, promptly "organized," and very rarely break down, even when they have been inoculated with pyogenic microorganisms.[6] In only one instance did an inoculated blood clot break down.

The drainage tube is of necessity a part of the technic of those who insist upon perfectly dry wounds. It would be illogical for them to close absolutely their wounds, for the dead spaces which necessarily exist in almost every wound must become filled with something, either blood or transudate, and this fluid something is according to the advocates of this method a thing to be feared and gotten rid of. The dead space may be exceedingly small, but what is true for the large must, in a measure, be true for the small dead spaces, and one can hardly conceive of a dead space too small to lodge bacteria and to contain food for them. But one cannot attempt to drain minute dead spaces nor, perhaps, any buf large ones. How then can the believers in the absolutely dry method explain their own good results?

The objections to the insertion of drainage tubes into wounds have been well summed up by Welch,[7] as follows:

First, they tend to remove bacteria which may get into a wound from the bactericidal influence of the tissues and animal juices. *Second,* bacteria may travel by continuous growth or in other ways down the sides of a drainage tube and so penetrate into a wound which they otherwise would not enter. We have repeatedly been able to demonstrate this mode of entrance into a wound of the white staphylococcus found so commonly in the epi-

[5] Johns Hopkins Hospital Reports, Vol. 2, No. 5, Surgical Fasc.

[6] Experiments on the so-called organization of the blood clot by Dr. Welch, Dr. W. T. Howard, Jr., and myself in the Pathological Laboratory of The Johns Hopkins University and Hospital, *vid.* Welch: Conditions underlying the Infection of Wounds, Am. Jour. of the Medical Sciences, November, 1891.

[7] Some considerations concerning antiseptic surgery. Md. Med. Jour., November 14, 1891.

dermis. The danger of leaving any part of a drainage tube exposed to the air is too evident to require mention. *Third,* the changing of dressing necessitated by the presence of drainage tubes increases in proportion to its frequency the chances of accidental infection. *Fourth,* the drainage tube keeps asunder tissues which might otherwise immediately unite. *Fifth,* its presence as a foreign body is an irritant and increases exudation. *Sixth,* the withdrawal of tubes left any considerable time in wounds breaks up forming granulations and thus both prolongs the process of repair and opens the way for infection. Granulation tissue is an obstacle to the invasion of pathogenic bacteria from the surface, as has been proven by experiment. *Seventh,* after removal of the tube there is left a tract prone to suppurate and often slow in healing.

The first and second objections are, I believe, original with Dr. Welch. I would add an *eighth* objection. Tissues which have been exposed to the drainage tube are suffering from an insult which impairs more or less their vitality and hence their ability to destroy or inhibit microorganisms.

THE OPERATIVE REDUCTION OF AN OLD DISLOCATION OF THE ELBOW[1]

This case is the most interesting one that we have had for some time. This little boy dislocated his elbow about four months ago. It was a dislocation of both bones of the forearm backwards. He could not flex his arm at all. Pronation and supination were very limited in extent. The bones were in the usual position, the forearm bent at an angle of 45 degrees with the straight line of the arm. Up to this time no one has succeeded in reducing an old dislocation of the elbow-joint without exsection of bones and usually a typical exsection. Recently F. Bassel-Hagen, of Heidelberg, has published all the cases he could collect, eleven in number, and in all of them there was more or less typical exsection of the bones made. This is the fourth case that I have operated upon. Heretofore I have always exsected the bones. It occurred to me that after all we could probably reduce these old dislocations if we could only overcome the shortening of the triceps muscle which ensues after the dislocation. The idea suggested itself to me from several cases of fracture of the patella which we have had, where we have brought down the patella sometimes three or four inches. In this case we cut through the olecranon where the two processes join. We then removed the new tissue which had filled up the space formerly occupied by the articular surface of the ulna, that is, the lower articular surface of the humerus, which was covered with new connective tissue. We excised that, and then dissected the triceps tendon well up on the arm, and by transverse cuts on its under surface we were able to draw it down as far as necessary in order to make it meet the ulna which had already been replaced. This is the first case of the kind on record. We have one to do tomorrow which I hope will result successfully. It is now nearly four weeks since this has been done. Although it pains the boy to move it, you see he can rotate it considerably, and there is already quite a little flexion. We shall certainly be able to flex it more than a right angle, and if we can extend it, as I am sure we can in time, that will be an excellent result.

[1] Presented before The Johns Hopkins Hospital Medical Society, Baltimore, April 3, 1893.

Johns Hopkins Hosp. Bull., Balt., 1893, iv, 97.

TWO CASES OF EXCISION OF THE KNEE-JOINT IN WHICH HANSMANN'S PLATES WITH ORDINARY SCREWS WERE EMPLOYED[1]

CASE 1.—Woman, 47 years old. Two months ago she had a miscarriage which was followed by pyaemia. Both knee-joints became infected. The right one recovered prior to her admission to the hospital. On admission, six weeks ago, the left knee-joint was distended with a puro-synovial fluid. This fluid was withdrawn soon after admission through an aspirating needle, and the joint subjected to a prolonged washing with a solution of hydrarg. bichlor. (1-1000). The pain, which had been great, subsided after the aspiration and washing, and the temperature, which had been 99° to 101°, became lower for about one week. Then the symptoms of pus in the joint reappeared and the aspiration and washing were repeated in two weeks, this time with perhaps less success than at first. The patient absolutely refused further operative treatment for three weeks. In the meantime the inflammation of the joint made rapid strides. The joint was distended to its utmost capacity with pus. The tissues about the joint were infiltrated and the skin was red and tense. Ultimately, and when the patient's general condition had become so bad that her life was almost despaired of, she consented to an operation.

A transverse incision was made through the skin and patella, then two longitudinal incisions, making with the first the letter H. The internal longitudinal incision opened a dissecting extracapsular abscess. The joint was, as I have said, filled with pus. The cartilages were still intact. The crural ligaments were softened, but had not yet parted. A horizontal slice about 1.5 cm. was taken from the tibia, and a somewhat thicker slice from the femur. Such portions of the femur cartilages as were not removed with this slice were shaved off subsequently. I make it a principle never to leave exposed cartilage in a wound. The walls of a dead space should never be of tissues which cannot furnish granulations readily. The bones were held together by Hansmann's plates and my screws.

The knee is already perfectly firm,[2] although it is only three weeks since the operation. The wound has healed absolutely *per primam,* notwithstanding the fact that the operation was performed through actively suppurating tissues, and notwithstanding possibly the still more important fact that the patient's vitality was at a critically low ebb at the time of the

[1] Probably the first report of cases treated by buried screws and Hansmann's plates. (W. S. H.) Presented before The Johns Hopkins Hospital Medical Society, Baltimore, December 18, 1893.

Johns Hopkins Hosp. Bull., Balt., 1894, v, 31.

[2] January 18, 1894. The knee became absolutely firm within five weeks of the operation. The patient is perfectly well and entirely free of pain.

operation. I have repeatedly called your attention to the objections to Hansmann's screws which, beyond the flange, have a shank long enough to project through the skin wound. They must be ultimately removed, and they necessarily lead to suppuration. My screws are so short that when screwed home they are almost flush with the plate. They are designed to remain in the wound. It has occurred to me that possibly staples over stiff wire might well replace the plate and screw method. The staples could be very fine and might be clinched on the other side of the bone if necessary.

Case 2.—Woman, 24 years old. This patient had a tuberculous knee-joint which was treated for many months with iodoform-glycerine injections, without much success. Excision was finally decided upon and performed four weeks ago. A modified Helferich's method of excising was employed. The bones are cut in such a way that the convex lower end of the femur fits more or less accurately into the concave upper end of the tibia. We usually make use of this method, or a modification of it, in excising tuberculous knee-joints. The semicircular cut into the head of the tibia sometimes reveals and partially or wholly removes tuberculous foci which might be overlooked if the bones were simply trimmed in the usual way. By this method, or rather a modification of it, the cartilage of the femur is thoroughly removed and the condyles so trimmed that any tuberculous invasion of them is almost sure to be exposed. In short, we make a virtue of necessity, for in trimming the bones to the desired shape we may eradicate the disease.

When the knee-joint has been excised in this way, and it has not been necessary to remove too much bone, the femur locks into the tibia so firmly when the leg is extended that there is little tendency to displacement. When the plates and screws are used the bones are held still more firmly in position.

Helferich's method of excising the knee-joint was devised for joints which are ankylosed in a flexed position. He believes that with the semicircular incision he gets less shortening of the limb than when he cuts out the usual wedge-shaped piece of bone. We are very much pleased with the screw and plate method. The results have been surprisingly gratifying. In the four or five previous cases in which we have used them the ankylosis has been absolute. In no case has there been suppuration, and in no case have the plates and screws caused the patient uneasiness.

CONCERNING INFLAMMATION AND SUPPURATION[1]

I am not prepared at present to entertain the notion that it might be practicable to reserve the term inflammation for lesions or symptoms caused by microorganisms, unless it was impossible to simulate what we should decide to call inflammation by any means except infection. For it is not always possible to say positively, from naked-eye observation, whether inflammation exists or not. Shall we withhold tentatively the term inflammation until the results of the bacteriological examination, however prolonged, are made known? And shall we accept a negative result as proof that microorganisms have not been or are not present? On the other hand, we may have an infection without the slightest outward manifestation of it.

For example, a recent case of my own. A cyst of the tongue, caused by *Staphylococcus aureus,* without a sign of inflammation. The cyst formed slowly, without pain and without infiltration or redness of the surrounding tissues. It was perfectly circumscribed, as large as a hickory-nut, and contained a perfectly clear, slightly viscid fluid. Pure cultures of *Staphylococcus aureus* were obtained.

The gonococcus is another microorganism which at times is a malignant pyogenic organism, although, as a rule, it does not produce in the tissues disturbance enough to be recognized as inflammation. We have found it quite recently in pure culture in pyarthrosis of the knee. Dr. Welch has recently found it to be the only organism in a case of multiple abscesses of the viscera and virulent ulcerative endocarditis. One or two similar cases of endocarditis caused by the gonococcus have already been reported.

Dr. Park believes that the so-called pyogenic membrane is a protection to the tissues against the invasion of pus, and proposes that it be called a *pyophylactic* membrane. Pyogenic he considers a misnomer. I agree with him that it might be well to drop the adjective pyogenic, but I should hesitate to recommend pyophylactic in its place. I did not suppose that the so-called pyogenic membrane, its name notwithstanding, was still believed to have a particular function. We regard this membrane merely as the expression or result of Nature's effort to repair a lesion, subcutaneous or

[1] Remarks in discussion of Dr. Roswell Park's paper, "On the consequences of hyperaemia and the pathology of inflammation and suppuration." American Surgical Association, New York, May 28-30, 1895.

Tr. Am. Surg. Ass., Phila., 1895, xiii, 249-251.

otherwise. The thick pleura, the masses of new connective tissue in tuberculous knee-joints, the thick hydrocele sac should not be called pyophylactic. The object of the thick hydrocele sac is not to protect the tissues against the invasion of pus.

Whatever the stimulus to the production of granulation tissue, these thick membranes are its products. They may be regarded as organized exudates in the sense of an organized blood clot or organized thrombus. König has shown that the fibrous tissue in tuberculous joints is produced by the organization of the fibrinous exudate.

Archepyon is hardly a suitable term for the contents of the usual old "cold abscess." The contents of these tuberculous abscesses is not, and never was, pus.

Dr. Park has omitted one microorganism which is of great surgical importance. It is *Bacillus aerogenes capsulatus* (Welch). Welch and Nuttall described this anaerobic bacillus, in 1892, as the cause of rapid formation of gas in the bloodvessels and tissues after death. It is a capsulated thick bacillus, from 3 to 6μ long. Does not form spores. It produces gas more rapidly after than before death. If the inoculated animal is killed soon after the injection, the bacillus develops rapidly and with the production of a large amount of gas throughout the body. The gas formation in the liver has riveted the attention of one German observer, who calls the infection Shaumleber (foam-liver). Fraenkel's Gasphlegmonen were undoubtedly caused by this bacillus. *Bacillus phlegmones emphysematosae* he calls it.

We have had considerable experience with this bacillus at The Johns Hopkins Hospital, thanks to Dr. Welch's prompt recognition of it. A few weeks ago we found it in the living subject, in a bullet wound of the knee-joint, infected twenty-four hours before admission to the hospital.

Dr. Bloodgood, the house surgeon, promptly and cleverly recognized "air" in the joint. We operated at once and found gas in the joint, and, to a slight extent, in the surrounding tissues. The bullet was found in the head of the tibia, about 3 cm. from its joint surface. *Bacillus aerogenes capsulatus, Staphylococcus pyogenes aureus,* and a streptococcus were cultivated from the joint contents. All these were present in great abundance. The joint was opened freely on both sides. An Esmarch rubber bandage was applied about 12 cm. above the joint so as to enable us to irrigate the joint without fear of absorption. The joint was irrigated and deluged with many gallons of a solution of corrosive sublimate, 1 to 1000. The patient, a boy about twelve years old, was very comfortable for two days. He then developed a temperature of about 39.5° C. and became restless, but did not complain of pain. The wound was promptly dressed and looked so

perfectly well that it was not opened. The next day, the temperature continuing and increasing a little, the wound was torn open and a most unusual picture was presented, but one which I think that I have seen more than once years ago.

To one who had seen Dr. Welch's pigeons and rabbits and Fraenkel's drawings the lesions were unmistakable. The muscles about the joint seemed in places to have melted into a thick purée-like paste, with peculiar purple-brown and Burgundy-slate colors. There was no distinct evidence of gas formation. There was no pus. The aponeuroses and the connective tissue between muscles were tinged a yellow-green. I feared from the very rapid and extensive lesions that even a high amputation would not save the boy's life. I had read of the almost uniformly fatal cases of Schede, Sick, and others, collected by Fraenkel, and knew that an attempt to save the limb meant almost certain death; so I amputated a little above the middle of the thigh, left the wound wide open, and put the patient into the hot-water bath. He was kept in this bath until he was thoroughly convalescent.

BICHLORIDE IRRIGATIONS[1]

In these cases of knee-joint irrigation we do not hope to do more than to greatly inhibit the activity of the microorganisms—to assist the tissues to destroy the microorganisms. It is rarely necessary to do more than incise an acute abscess; the tissues do the rest. And yet we know that the tissues about the abscess have been invaded by the pyogenic microorganisms. In irrigation of the knee-joint we do not expect to reach the microorganisms outside of the joint.

In the last case reported by Dr. Finney—the one with triple infection—I do not feel at all sure that we could not have taken care of the joint itself. We amputated because in a few days we found the tissues in the thigh almost up to the hip-joint invaded by the organisms to a shocking extent, with lesions characteristic of the air-producing bacillus.

That solutions of bichloride of mercury are more efficacious than salt solutions in destroying and inhibiting pyogenic organisms outside of the body we have sufficient proof. There is also abundant clinical, if not wholly conclusive experimental evidence that the same is true in the tissue spaces, in joints, etc.

The irrigation of the urethra in the treatment of gonorrhoea furnishes a good clinical example of the benefits to be derived from solutions of corros. sub. Here, too, the specific microorganisms have been demonstrated in the tissues outside of the urethra.

[2] I speak from a great deal of experience—from daily observations for five years (1880-85) in the Roosevelt Hospital Dispensary, New York. In this work I was very ably assisted by Drs. Richard Hall and Frank Hartley of New York. The salt solutions are worse than ineffectual in the treatment of gonorrhoea. With them we never succeeded in aborting a case of gonorrhoea, either in private or dispensary practice, but we constantly induced a cystitis and epididymitis. With the bichloride irrigation, not a single case of cystitis or epididymitis occurred in these five years. I think that we have had the same experience in the dispensary here. Dr. James Brown told me less than a year ago that he had never produced cystitis or

[1] Remarks in discussion of Dr. John M. T. Finney's paper, "Pyarthrosis." The Johns Hopkins Hospital Medical Society, Baltimore, October 7, 1895.

Johns Hopkins Hosp. Bull., Balt., 1895, vi, 164.

[2] This paragraph refers to an original contribution of Dr. Halsted in the treatment of gonorrhoea by dilute bichloride solutions.—Editor.

epididymitis with bichloride irrigation. In private practice it is very common, indeed it is the rule, to abort a gonorrhoea within a week or ten days with bichloride irrigation. Previous to the use of this irrigation I used to dread to have a gonorrhoea case come to my office; after its introduction I was glad to see them. The treatment became so popular that certain specialists in New York said that they would never use it because it was ruining their practice. Men after a few visits were cured. Nor would they return when a fresh urethritis was contracted. Furthermore, they taught their friends how to treat themselves. It would be too much of a digression to give the details of this treatment at this time. But I must ask your permission to say that everything depends upon the intelligent use of the method. The required strength of the solution is determined by the use of the microscope and by the tolerance of the particular urethra. The strength to be used varies from 1 : 200,000 to 1 : 25,000. A tolerance of the stronger solutions has, usually, to be acquired. Men with red hair have, as a rule, sensitive urethrae.

[3] The gonococci disappear promptly from the urethral discharge after irrigation with solutions of corrosive sublimate, but are uninfluenced, apparently, by irrigation with the salt solution.

[3] Reference to counting the bacteria as a method of estimating the value of the antiseptic solution.—The Editor.

CONCERNING DRAINAGE AND DRAINAGE TUBES[1]

I cannot endorse Dr. Moore's views as to drainage of the knee-joint after suture of the fractured patella. We rarely put drains of any kind into the knee-joint, even though it be infected. A drain can relieve tension, but it cannot dispose of all of the organisms of an infected joint; the tissues have to take care of these in a large measure, and they can often do this better without a drain than with it. A drain produces invariably some necrosis of the tissues with which it comes in contact, and enfeebles the power of resistance of these tissues toward organisms. But given necrotic tissues plus infection, a drain becomes almost indispensable. In abdominal cases, for example (I am now speaking of the principles of drainage in general), it is not sufficient to drop a drainage tube or a piece of gauze down into the middle of a necrotic area; the entire necrotic area should be circumscribed by gauze packing and excluded in this way from the rest of the peritonaeal cavity. No drainage at all is better than the ignorant employment of it.

[1] Remarks in discussion of Dr. Charles A. Power's paper, "The question of operative interference in recent simple fractures of the patella." American Surgical Association, New Orleans, La., April 19-21, 1898.

Tr. Am. Surg. Ass., Phila., 1898, xvi, 103.

CARREL-DAKIN METHOD OF THE TREATMENT OF INFECTED WOUNDS. ANTISEPTICS IN THE ASEPTIC PERIOD[1]

We were most fortunate in having with us last winter Dr. Joseph S. Lawrence, who for several months had been in charge of the bacterial work of the American Ambulance at Neuilly and had thoroughly familiarized himself with the details of the new antiseptic work. Dr. Lawrence made all of our bacterial counts and carefully supervised the technical details of the wound-treatment. We were able to confirm unqualifiedly the claims made for the method by Carrel and Dehelly, Depage, Tuffier, Debaisieux, Lagasse, and some others.

At the outset of our work with the Dakin-Daufresne solution we repeated on the human subject the experiments made by Carrel on dogs at the Rockefeller Institute.[2] Our patients readily consented to the experiments, which consisted merely in the removal of two squares of skin at symmetric points on the abdomen and observing the process and rate of healing under various contrasted conditions. The square defect on one side of the abdomen would be treated with the Dakin solution, and on the other either without an antiseptic or with naphthalin, blue ointment, nitrate of silver, *et al.* The healing under the Dakin solution was marvelously rapid, and the results so uniform that we accepted it as a standard for comparison with other methods, such as dry scab, moist blood-clot, dry cell, grafts deprived of epithelium and applied inside out, etc. Although not quite prepared to report our results, we can confidently affirm that the granulating wounds treated with the Dakin solution healed much more rapidly than any treated by other antiseptics.

Are you not surprised to note the absence of any reference to dead spaces in the writings either of those who extol or those who condemn the Carrel method? We know, of course, as Moynihan has emphasized in a recent paper, that fresh wounds of soft parts may, after scrupulous toilet, and without the employment of antiseptics, be closed with a fair prospect of healing by first intention; and we have frequently observed that even after amputation through infected tissues the undrained wound may heal *per primam,* provided that no dead space is left. If a dead space cannot be

[1] Letter to Dr. William W. Keen, December 14, 1917.
In: "The treatment of war wounds" (W. W. Keen), Phila., 1918, 2d ed., 252-259.
[2] Jour. Amer. Med. Assoc., December 17, 1910.

avoided without prejudicing the vitality of the tissues used to occlude it, the apposed soft parts may still unite primarily if the dead space at the end of the sawed-off bone is drained.

Having convinced myself of the remarkable effect of the Dakin-Daufresne solution upon infected wounds, I cherished the hope that possibly involucral cavities, if sterilized to the required degree, might, after closure, fill with granulations before the inhibited organisms would recover sufficiently to defeat the healing process. As every surgeon knows to his mortification, cases of osteomyelitis in which the sequestrum has or has not been removed may go from clinic to clinic for twenty years or more in the hope of having their fistulous tracts healed. It would, therefore, be a great boon to both patient and surgeon if by the Carrel method the old involucral cavities could be healed.

In four cases last year Dr. Dandy, our resident surgeon, irrigated for from twenty-five to thirty days with the Dakin solution, according to the Carrel method, the properly prepared involucral cavities, and then, the microorganisms having been reduced for six or more days to about 1 in 10 fields (the counts were made by Dr. Lawrence), the soft parts were trimmed and the wounds closed. For about six weeks in one case, eight weeks in two cases, and three weeks in a fourth the wounds remained closed and without evidence of revivement of the bacteria. Then the tissues became slightly inflamed and the wounds opened.

In a fifth case a fracture of the operatively reduced involucrum occurred and the fragments were wired together. In this instance the Carrel irrigation was continued for about two months—until the bony cavity had filled and the wound healed. Now, six months later, the wound is still firm and the fracture united.[3] So, too, in circumscribed bone abscesses, thanks to the care and interest of Dr. Dandy and Dr. Lawrence, we have had admirable results with the method when the irrigation was continued until the cavity became filled with the new tissue.

Evidently, in the unsuccessful cases, the bony cavities with eburnated involucral walls produced granulations so slowly that the inhibited organisms recovered before the dead spaces became filled with living tissue. Thus the Carrel method will fail if the dead space is too large or its walls are too feeble to furnish sufficient granulation tissue in the required time. Dead spaces, and not alone devitalized bone or soft parts, must surely be a contributing cause of the failure of the Carrel method in many cases of compound fracture. Even in amputations the dead space between the end of

[3] Fancy what the result would have been in this case had the wound not been sterilized.

the bone and the muscles might be responsible for the defeat of the surgeon's best efforts. Granulation tissue must fill the empty space before the bacteria in its fluid contents revive, otherwise the wound will break down. The walls of an infected dead space, enlarged from exudate or perhaps from a haemorrhage, become tense and relatively devitalized, and thus the infection may spread to parts of the wound which have healed, and beyond. One should not demand the impossible from the Carrel-Dakin treatment.

In civil practice we should, I think, sterilize every granulating wound, whether abscess, sinus, or superficial ulcer; and attempt the sterilization of fistulae. Surgeons will ultimately appreciate the magnitude of the lessons taught by Carrel, chief of which is that wounds may be practically sterilized by the constant contact of mild antiseptics. The contributions of Dakin are of almost equal importance, and indicate that it is chiefly the chemist to whom we must now look for further developments in the treatment of wounds in general.

Antiseptics in the Aseptic Period.[4]—In the Surgical Clinic of The Johns Hopkins University we have never abandoned the use of chemical antiseptics. The surgeon who has lived in the days before Listerism needs no modern proof of their value. So far back as 1884 we had irrefutable confirmation of Carrel's view of the inhibitive action of mild antiseptic solutions. Gonorrhoea was promptly cured by frequent irrigations of very large quantities (3000 c. c.) of solutions of the bichloride of mercury as weak as 1:50,000, or even 1:100,000. The strength of the solution could be gradually increased to 1:20,000. From day to day we noticed the rapid diminution in the number of the Neisser cocci.

Since the first years of The Johns Hopkins Hospital the treatment of our infected joints has been as follows: An Esmarch bandage is applied above the affected joint to prevent absorption of the antiseptic; the joint is opened freely, flushed with the antiseptic solution for five or ten or even fifteen minutes, and then closed. If necessary, the procedure is repeated in a few days, and then perhaps again. The results in these cases alone should convince one of the value of antiseptics.

Further proof (if, indeed, fresh proof were needed) of their action we have from year to year in the results of the blood-clot treatment of old involucral cavities. These cavities are cleaned with meticulous care. Everywhere, both in bone and soft parts, only freshly cut surfaces remain as walls

[4] A further reference to Dr. Halsted's original contribution to the treatment of gonorrhoea with dilute bichloride solutions. Also a reference to Dr. Halsted's contribution to the counting of bacteria as a method of estimating the effectiveness of the antiseptic solution.—The Editor.

of the dead space. Pure carbolic acid is poured freely into the cavity (formalin may be as good or better) and scrubbed over all the raw surfaces for several minutes. Then for a prolonged period the wound is flushed with gallons of a corrosive sublimate solution—1 : 1000. The wound is loosely closed with a buried continuous wire suture, the Esmarch bandage removed, and the cavity allowed to fill with blood. Many layers of silver-foil are laid over the line of the suture, and over this the paper. The wound should not be investigated for two or three weeks unless there is reason to believe that the clot has broken down from infection.

THE BLOOD CLOT IN THE MANAGEMENT OF DEAD SPACES IN THE TREATMENT OF WOUNDS

THE TREATMENT OF WOUNDS WITH ESPECIAL REFERENCE TO THE VALUE OF THE BLOOD CLOT IN THE MANAGEMENT OF DEAD SPACES[1]

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To drain or to obliterate with the greatest care all of the dead spaces of a wound is still an almost universally accepted precept of surgery; and surgeons have a wholesome fear of the presence of blood in wounds.

Having referred to the attempts of Maas, Neuber and others to dispense with the use of drainage tubes, Küster[2] expressed himself on the subject of blood in wounds as follows: "Moreover, it soon became evident that the presence of blood in any wound represented a great danger, and after a while one seldom heard of any such experiments"—experiments to close a wound without providing for its drainage or for the obliteration of its dead spaces.

Von Bergman,[3] in an address which he delivered on the antiseptic treatment of wounds a few years ago, says:

"That organic material which with the greatest ease becomes the seat and essential part of putrefactive processes is the blood, which streams or trickles

[1] Johns Hopkins Hosp. Rep., Balt., 1890-91, ii, 255-314. (Reprinted.)
Also: Maryland M. J., Balt., 1891, xxiv, 529-533.

[2] E. Küster, Ueber die Anwendung versenkter Nähte. Archiv. für klin. Chirurgie, 1884, Bd. xxxi, Heft 1, S. 133.

[3] Schede, Ueber die Heilung von Wunden unter dem feuchten Blutschorf. Verhandlungen der deutschen Gesellschaft für Chirurgie, 1886, S. 65.

from the divided vessels of a wound and collects in its deeper parts, particularly in its recesses and pockets. Since it is the business of the surgeon to avoid doing anything which could give rise to decomposition in a wound, it should be his care to provide for the exclusion of a fluid so prone to decompose, one of the most important if not the most important of the achievements of antiseptic surgery. . . . .

"Formerly, so long as one regarded the blood as the plastic material which fills the holes, as the glue and cement which should stick together the edges of the wound, its presence seemed not only good but desirable—now, since one knows that the most feared and most dangerous wound diseases arise from its decomposition, one struggles with all one's might to keep the wound freed from it. The surgeon, who has not arrested the bleeding with the most scrupulous care, will in vain look for results for success with his antiseptic technique."

Lister has done more than any one perhaps to perpetuate this great fear—the fear of blood in wounds—of prae-antiseptic times. For twenty-three years the eyes of every surgeon have been turned towards Lister, who has rarely lost an opportunity to emphasize the importance of wound drainage. His efforts are still directed to the best means of taking care of the discharges from wounds—to the perfection of a dressing. In 1875[4] he expressed himself on the subject of drainage as follows:

"Two days later, or six days after the operation, the pain in the limb, of which he had complained at the last dressing, had left him; but a considerable serous stain being still found on the gauze, the drainage-tube was continued, though shortened by cutting off a piece from the deeper end."

Two days later:

"The wound being dressed the line of incision was found entirely healed, except at the point occupied by the drainage tube, and the serous stain on the dressing was so much diminished that I reduced the little tube to a quarter of an inch in length, and allowed three days to pass before the next dressing. On then exposing the wound, however, I was disappointed to find the serous stain on the gauze fully as great as on the last occasion, and pressure on the skin in the vicinity of the wound caused a drop of clear serum to escape. This had never been seen before and implied that the shortened drainage tube had not been answering its purpose completely, but had permitted a certain amount of serum to accumulate; and slight as this accumulation was, I knew from experience that it was enough to perpetuate serous oozing by the tension which it occasioned. I therefore substituted for the short drainage tube another of the same calibre, but twice as long—viz., half an inch, being as deep as it could be passed without violence, and dressed again in two days. The result was such as I had hoped. There was an almost entire absence of serous stain on the gauze, and nothing could be pressed out of the tube, which was now again slightly shortened. The dressing was then left untouched for four days, when the drainage tube was found

[4] Lancet, 1875, p. 436.

lying out of the wound, having been forced out by the consolidation going on in the interior. There was almost no stain on the gauze, and nothing could be pressed out of the orifice where the tube had been. But to return to the point which this case is intended to illustrate—viz., the value of the drainage tube in the later stages of wounds. Supposing that instead of substituting a longer tube for the shorter one on the eighth day after the operation, when a little serum was found to have accumulated, I had then given up the use of the tube altogether, the possibility is that by the time of the next dressing the outlet at the integument having become partially occluded by granulation and contraction, a greater amount of serum would have been pent up in the cavity, and in course of time the additional tension so occasioned would have led to suppuration and to the opening up of the nearly cicatrised wound."

In 1866,[5] at the very beginning of his experiments with carbolic acid—at his third case—he described the organization of a small blood clot. He observed the case—a compound fracture of the leg—with an intense interest. I shall quote from his account of the case that part which relates to the organization of the blood clot.

"On the 7th of June, nearly three weeks after the accident, an observation of much interest was made. I was detaching a portion of the adherent crust from the surface of the vascular structure into which the extravasated blood beneath had been converted by the process of organization, when I exposed a little spherical cavity about as big as a pea, containing brown serum, forming a sort of pocket in the living tissues, which, when scraped with the edge of a knife, bled even at the very margin of the cavity. This appearance showed that the deeper portions of the crust itself had been converted into living tissue, for cavities during the process of aggregation, like those with clear liquid contents in a Gruyère cheese, occur in the grumous mass which results from the action of carbolic acid upon blood; and that which I had exposed had evidently been one of these, though its walls were now alive and vascular.

"Thus the blood which had been acted upon by carbolic acid, though greatly altered in physical characters, and doubtless chemically also, had not been rendered unsuitable for serving as pabulum for the growing elements of new tissue in its vicinity."

Although perfectly familiar with the organization of the blood clot it has, apparently, never occurred to Lister to make a systematic effort to utilize the blood clot and to imitate nature's method of disposing of the dead spaces in wounds.

He has taught us what can be done under the cover of antiseptics. One may maltreat the tissues to any extent—mutilate the wound during the operation in every possible way, cut off by ligatures the circulation in large masses of tissue, produce extensive areas of superficial necrosis by irrigation

[5] Lancet, 1867, p. 328.

with antiseptic solutions, stuff the wound with gauze and drainage tubes, tear out the stuffing and with it the granulations which have grown into it, restuff, etc.—and still the wound may heal without suppuration, without septic inflammation, and in a way which is, perhaps, altogether satisfactory to the surgeon.

But now that wound infection is for many surgeons almost a thing of the past, we may ask ourselves if, after all, our wounds are ideal wounds. One naturally hesitates to attempt to give one's notion of an ideal wound. His ideal wound of today may not be his ideal wound of next year or even of tomorrow. I conceive an ideal wound to be one which immediately after the operation is reduced to the condition of a nonpenetrating subcutaneous wound, and which is as free as this is from the dangers of infection. By a "nonpenetrating" wound I mean one in which the skin is not penetrated and I use the term nonpenetrating because the penetrating wounds which used to be made in tenotomy, joint and other operations were called *subcutaneous* wounds. A wound which has been irrigated with solutions of carbolic acid, corrosive sublimate, or other disinfectants labors under the disadvantage of a more or less extensive area of superficial necrosis from which the subcutaneous wound is free. The subcutaneous wound is not exposed to the dangers which attend the introduction of drainage tubes, ligatures and sutures, nor to the greatest of all dangers for the surgeon's wound, that of infection from the hands of the operator and his assistants. The drainage tube is still one of the chief features of the modern treatment of wounds despite the systematic efforts of many surgeons for the past ten or more years to dispense with its use.

Among the first to propose a method for securing the healing of wounds without drainage tubes was Kocher.[6] He recommended a secondary suture. His method was complicated, necessitated several dressings and a second operation, was annoying to the patient and exposed the wound unnecessarily often to the dangers of infection.

In 1884 there appeared from Neuber[7] a valuable contribution to the subject of the abolishment of wound drainage. He attached great importance to the complete obliteration of all the dead spaces in wounds, recommended for irrigation a sterilized 0.6 per cent salt solution, and provided for drainage by "canalization" and by loose stitching. For the obliteration of dead spaces he had at his disposal the following means: compression from without, buried sutures, inverting stitches, flap implantations and firm coaptation of the resected ends of bones.

[6] Ueber die einfachsten Mittel zur Erzielung einer Wundheilung durch Verklebung ohne Drainröhren. Th. Kocher. Volkmann's Sammlung klin. Vorträge. No. 224.

[7] Vorschläge zur Beseitigung der Drainage für alle frischen Wunden. G. Neuber. Kiel, 1884.

In the same year Küster [8] published his well known article on the employment of buried sutures.

Impressed by the work of Küster, Neuber and others and entertaining with them the same fears of blood in wounds, it was my practice for several years to attempt with the utmost care to obliterate the dead spaces in wounds. The results were gratifying but the technique was often very tedious. For example, after an amputation of the thigh it would not infrequently take an hour to obliterate thoroughly all the dead spaces. The mechanical problems were sometimes quite difficult, and one was perpetually annoyed by the fear that he might strangulate the tissues included in the sutures. After a time I became convinced that it was impossible to obliterate thoroughly all the dead spaces in some wounds, and I observed that wounds in which the dead spaces were not obliterated healed throughout by first intention just as regularly as did the other wounds. I was therefore quite prepared to welcome Schede's article on the healing of wounds under the moist blood scab. This contribution of Schede's [9] I believe to be the greatest which has been made to the technique of surgery since the introduction of antiseptic methods by Lister.

That Schede was impressed by the importance of the communication which he has made one may infer from his introduction.

He says:

"I am fully aware that it is a thankless task to come once more before this august body to advocate a new method of treating wounds, and surely I should not have the courage to do so if I did not believe that what I have to communicate to you today deserves because of its essential importance to occupy a higher plane than the ordinary modifications of the antiseptic wound dressing, and if I were not firmly convinced that you will recognize in what I have to say a real contribution to our science. . . . . It has required but a short experience with antiseptic surgery to enable us with astonishment to recognize that even very large blood clots in open wounds do not necessarily undergo destruction and decomposition, that they do not necessarily give rise to inflammation and accidental diseases, but that they can take on changes which one may designate as 'organization of the blood clot' and which one can compare with the conversion of the thrombus in ligated blood vessels."

The immortal John Hunter was many years in advance of his times when he expressed himself on scabbing and the organization of the blood clot as follows:

"In many deep-seated wounds, where all the parts have remained in contact, those underneath will unite much better if the surface be allowed to

[8] E. Küster, *loc. cit.*

[9] M. Schede, Ueber die Heilung von Wunden unter den feuchten Blutschorf. Verhandlungen der deutschen Gesellschaft für Chirurgie, 1886.

scab. Some compound fractures (more especially where the external wound is very small) should be allowed to heal in the same way; for by permitting the blood to scab upon the wound, either by itself or when soaked in lint, the parts underneath will unite, the blood under the scab will become vascular, and the union will be complete even when the parts are not in contact. . . . . Many wounds ought to be allowed to scab in which this process is now prevented; and this arises, I believe, from the conceit of surgeons who think themselves possessed of powers superior to nature, and therefore have introduced the practice of making sores of all wounds."

In 1832 Wardrop [10] reported a remarkable case of healing under a scab. The wounded surface was, he said, the largest that he had ever beheld. It arose from the ablation of a diseased breast. The wound healed under a crust of blood which was not disturbed for thirty days.

Volkmann [11] has observed the blood clot remain in the clefts of bone for six weeks and more without becoming fluid, without undergoing decomposition and without causing any wound disturbance, and advises that it be left undisturbed. We are indebted to him for the most classical description of the macroscopic changes which take place in the blood clot of an aseptic open wound. He depicts the clot as black and glistening and apparently unchanged for six or eight days, then as consumed by granulations or gradually shrinking and changing color from black to a leather and then to an orange tint and forming at last a moist scab which drops off when cicatrization is complete. But Schede was the first to take advantage systematically of the little understood properties of the blood clot. He regarded the blood as merely a plastic material possessed of high powers of organization. From experiments of Nuttall, Prudden, Buchner, Lubarsch, Stern and others we know that the blood possesses disinfectant properties toward certain species of bacteria. Human blood serum does not appear to be injurious to the multiplication of the staphylococci and streptococci of suppuration, so that we cannot attribute the beneficial results obtained by healing under the blood clot to any direct disinfectant properties of the blood upon the pyogenic micrococci, but such properties may come into consideration in the prevention of some other forms of wound infection.

[10] Lancet, 1832-3, ii, 653.

[11] Beiträge zur Chirurgie.

SUMMARY OF ALL OF THE WOUNDS TREATED WITHOUT DRAINAGE AND WITHOUT DEAD SPACE OBLITERATION— "BLOOD CLOT WOUNDS"

FROM THE OPENING OF THE HOSPITAL IN MAY, 1889, TO JUNE 1, 1890

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NOTE.—There were no deaths. Of the clean wounds, two suppurated primarily; *vid.* pp. 82 and 83.

I. UNCLASSIFIED OPERATIONS

Twenty-five cases. Nos. 2, 76, 78, 98, 105, 145, 160, 226, 241, 243, 284, 314, 346, 360, 377, 398, 421, 426, 445, 451, 470, 473, 479, 483, and 484.

Typical healing in 22 of the cases. Primary suppuration in two cases, Nos. 105 and 160. Haemorrhage in one case, No. 473, which necessitated the opening up of the wound.

EXAMPLE 1.—*Exsection of an elbow which had been crushed by the wheels of a horse car. Typical healing.*—No. 398. Dominick Cassine, colored, aet. 45, was admitted to the hospital March 17, 1890, within thirty minutes of the time of the accident. He had fallen from the front platform of a horse car. At least one of the wheels of the car had passed over his left elbow. The injury sustained was about as great as is possible in such an accident. The elbow felt like a bag of bones. The skin was broken through in three places and was badly contused on the arm and forearm as well as about the elbow.

Operation.—The existing wounds were enlarged; lacerated pieces of the triceps muscle, fragments of the lower end of the humerus and the olecranon process of the ulna were removed. Three or four longitudinal incisions were made through the skin which was undermined in all directions. The oozing of blood, which was considerable, was purposely not checked. The entire upper extremity was placed first in a solution of corrosive sublimate

(1-1000) for about three minutes, and then in a solution of carbolic acid (1-30) for about five minutes. The wound was then allowed to fill with blood. No stitches were taken. The arm, the elbow, and the upper part of the forearm were wrapped with strips of protective about one inch wide. Iodoformized gauze was placed over the protective, and over all a very large dressing of sterilized gauze. The arm was put up in an extended position. The blood clot which occupied the wound must have been as large as a man's fist.

March 21st.—The patient's pulse and temperature have been about normal ever since the operation. The highest temperature was 38.1° C. The wound is dressed, first, because the patient complains of a little pain in his fingers, and second, to satisfy our curiosity about the condition of the blood clot. The elbow is in excellent condition. Each one of the cuts is filled with a protruding blood clot.

April 2d.—The wound is redressed. The organization of the blood clot seems to be complete. The protruding portions of it are bright red and bleed when gently scratched.

April 12th.—The patient is discharged well.

October 14th.—The patient presents himself at the hospital for examination. The elbow is a remarkably good one. The patient can extend, flex, pronate and supinate the left elbow perfectly. He cannot, however, execute these movements, particularly extension, with quite the normal force.

Example 2.—*Extirpation of the head of the femur for ununited intracapsular fracture of the neck of the femur. Typical healing.*—No. 284. Henry Franklin, aet. 50, was admitted to the hospital January 16, 1890. In April, 1889, patient fell from a ladder and sustained a fracture of the neck of the femur. The physician who treated him did not at first recognize the nature of the injury, and after keeping him in bed for three weeks without a splint advised him to get up and walk. This the patient was unable to do. Then the physician put on a splint of some kind and kept the patient in bed for five weeks. At present the patient can, for a moment, bear his weight on his left leg. It gives him great pain to do so. He refers the pain to the upper part of his thigh and particularly to his knee. The pain with time has increased rather than diminished.

The patient says that he prefers to die than to live as he is and is willing to expose himself to the risks, however great, of any operation which offers to him a chance of being benefited.

Examination.—The leg is adducted and rotated outwards. The real shortening is about 5 cm., the apparent shortening 8 cm., and the measured shortening (measured from the anterior superior spine of the ilium to the external malleolus) 3.5 cm. The femur rotates on its own long axis. Diagnosis: intracapsular fracture of the neck of the femur.

Operation, January 17, 1890.—External longitudinal incision about 22 cm. long. The great trochanter was chiseled off flush with the bottom of the digital fossa. The loose head of the femur was found in position in the acetabulum and removed. It was slightly excavated. The ligamentum teres had been ruptured and not a trace of it was to be seen on the head of the femur. The neck of the femur had been absorbed. The divided muscles were loosely stitched together by a few buried silk stitches. Inasmuch as a

considerable amount of blood continued to ooze from the deeper parts of the wound I introduced a narrow strip of gauze to the bottom of the wound—into the capsule of the joint. I feared that the blood might be dammed up by the tense tissues about the joint. The wound was closed by buried skin sutures and dressed with gauze.

January 18th.—The gauze plug is removed and the large dead space which it occupied allowed to fill with blood.

February 8th.—The wound is dressed. It is typically healed. A Volkmann's extension apparatus is applied.

April 12th.—Patient is allowed to walk with crutches.

October 1st.—Patient walks very well and without pain but still wears a Volkmann's side splint. He is greatly pleased with the result of the operation.

EXAMPLE 3.—*Operation for the cure of deformity resulting from a subluxation and fracture of the internal cuneiform bone. Typical healing.*—No. 426. Miss —— was admitted to the hospital April 15, 1890. Eighteen months ago the horse which she was riding fell and rolled upon her left foot which was caught in the stirrup. The surgeon in attendance reduced more or less completely a dislocation of some kind which had caused a deformity conspicuous enough to attract the attention of the patient.

Ten days after the accident, while attempting to walk on crutches, the patient slipped and fell and reproduced the original deformity. The dislocation was again reduced, and a few days later again by accident produced and once more reduced. In about four months patient began to walk, and in a little more than a year was able to dance. About three months ago the pain in her foot, which for a time had almost vanished, returned, and since its return has steadily increased. Now it is severe enough to incapacitate her from walking.

Examination.—The internal cuneiform bone is subluxated inwards and much enlarged. The foot has lost its arch and is abducted at the scaphoid-cuneiform articulation.

Operation.—The internal cuneiform bone was fully exposed by a long internal longitudinal incision. It was found to have been fractured as well as subluxated. The fracture had united with the formation of considerable callus. The internal cuneiform bone with the exception of a small disc which included the anterior surface of the bone was chiseled out. It was necessary to exert a great deal of force to restore the foot to its proper position. The cavity resulting from the extirpation of the internal cuneiform bone was allowed to fill with blood. The wound was closed with buried skin sutures, covered with gutta-percha tissue and dressed with gauze. The foot was maintained in the equino-varus position by a plaster of Paris splint. The small disc of the internal cuneiform bone was left with the hope that from it the blood clot might be converted into bone.

April 18th.—The wound is dressed and has united perfectly. The blood clot seems quite firm. A new and close fitting plaster of Paris splint is applied.

May 18th.—The foot seems to be in perfect position. The blood clot feels already as hard as bone. The patient is permitted to walk on crutches.

November 1st.—The position of the foot is still perfect. The patient can walk many miles without the slightest discomfort. She believes that the right foot is as strong and as perfect as the left one.

EXAMPLE 4.—*Operation for the cure of pronation and drop wrist, the result of a fracture of the radius and ulna. Typical healing.*—No. 484. Conrad Pilgrim, aet. 18, was admitted to the hospital May 27, 1890. Four months ago patient broke both bones of his left forearm about 8 cm. above the wrist. When the splints were removed patient was confident that his arm had not been properly set. He has not been able to extend the wrist or do any but the lightest work since the accident.

Examination.—Patient's left forearm is strongly pronated and cannot be supinated. He carries his hand in the drop wrist position but is able to extend his wrist feebly. I have several times noticed this tendency to drop wrist in fractures of the forearm which have united in the position of extreme pronation. The forearm being pronated the hand must drop unless held up voluntarily by the patient. The patient soon wearies of the constant effort and the hand falls.

Operation, May 30, 1890.—Lateral incisions, 10 cm. long, over radius and ulna. The bones which were not adherent to each other were chiseled through at about the junction of their middle and lower thirds. The lower fragments were rotated outwards with considerable force. The muscles which resisted the outward rotation were necessarily twisted. The wound was stitched with buried skin sutures, covered with gutta-percha tissue and dressed with gauze. The forearm was flexed on the arm and the extreme supination maintained by a plaster of Paris splint.

June 10th.—The dressing is removed. The wound is healed throughout. The arm and forearm are again put up in a plaster of Paris splint.

October, 1890.—Patient presents himself for inspection. He can pronate and supinate his forearm very well; can extend his wrist as forcibly as ever, he thinks, and is able to do hard work of all kinds.

EXAMPLE 5.—*Subtrochanteric osteotomy and tenotomies for the cure of deformity resulting from tuberculous hip-joint disease. Typical healing.*—No. 445. Charles Love, aet. 10, was admitted to the hospital May 1, 1890. Five years ago the patient began to complain of pain in his right hip and right knee. The hip soon began to swell. An abscess formed quite rapidly and opened spontaneously in several places. The sinuses persisted for two years and then closed.

Examination.—The right thigh is adducted, rotated in and flexed at about a right angle to the body. The hip is not dislocated. The anchylosis at the hip-joint is apparently a bony one.

Operation, May 7, 1890.—Open incision of the adductor muscles and of the tensor vaginae femoris muscle. Subtrochanteric osteotomy. The thigh could then be extended and abducted. The wounds were loosely closed by buried skin sutures, covered with gutta-percha tissue and dressed with gauze. The thigh was put up in a plaster of Paris splint in an extended and strongly abducted position. We ordinarily abduct the thigh until there is apparent lengthening of the abducted limb.

May 31st.—The original dressing is removed. All the wounds are perfectly healed.

EXAMPLE 6.—*Exsection of a portion of the radius and of the ulna for contraction of the flexor muscles of the forearm. Typical healing.*—No. 377. Clara Albert, aet. 30, was admitted to the hospital March 17, 1890. When about one year old the patient's right little finger was crushed in the cog-wheels of a sewing machine. The wound became much inflamed and was an open sore for six or more weeks. In about five years the right hand had become strongly flexed upon the forearm. Two years later the patient was operated upon and was compelled to wear splints for three or four years. In a short time the hand became flexed again and has remained so ever since.

Operation, March 20, 1890.—A transverse dorsal incision about 4 cm. above the wrist joint was made through the skin and extensor tendons down to the bone. About 3 cm. of the radius, of the ulna, of the extensor tendons and of the skin were excised. The bones were sewed together with strong silk. The skin wound was united by buried skin sutures of fine silk, covered with gutta-percha tissue and dressed with sterilized gauze. The arm, forearm and hand were encased in the plaster of Paris splint.

April 7th.—The wound is dressed. It has healed in the typical way. The patient can already flex and extend her fingers.

EXAMPLE 7.—*Arthrotomy for rupture of the posterior crucial ligament. Typical healing.*—No. 346. John H. Smith, aet. 22, was admitted to the hospital February 26, 1890. About four weeks ago the patient was sitting in a chair with his legs crossed and strongly flexed. Upon suddenly extending them he "felt something slip" in his left knee joint and found himself unable to fully extend it. With the assistance of a cane he could walk without pain. About two weeks ago while manipulating his knee he unexpectedly succeeded in straightening it. About one week ago from a misstep the same slipping of something in the joint and the flexion of the joint recurred.

Examination.—The leg is flexed on the thigh at an angle of about 135°. There is a little fluid in the knee joint. When the leg is strongly flexed there appears to be an almost inappreciable subluxation forwards of the head of the tibia. On forced flexion the patient complains of pain which he refers to the articular surface of the outer tuberosity of the tibia. On forced extension the patient refers the pain to about the centre of the popliteal space.

Operation, February 29, 1890.—The joint was freely opened by a long antero-internal incision. The incision was curved outwards at its extremities, its lower end dividing a portion of the ligamentum patellae and its upper end some of the fibres of the vastus internus muscle. The joint contained about four or five c. cm. of a clear straw-colored fluid and its synovial membrane was considerably injected. The posterior crucial ligament was found to be torn away from its attachment to the outer surface of the internal condyle of the femur and to have carried with it quite a large piece of bone in three fragments. Two of these fragments were attached to the ligament. The other fragment was loose in the joint and had made for itself a depression in the cartilage covering the antero-external surface of the internal condyle of the femur. A cavity about 2.5 cm. in diameter and about

0.5 cm. deep was made in the outer side of the internal condyle of the femur by the tearing away of the posterior crucial ligament. Extension of the leg had been prevented by the impaction of one of the fragments of bone between the femur and tibia at the back part of the joint. With the liberation of this fragment the joint could be extended. The posterior ligament was cut away at its tibial attachment and removed. The wound was loosely closed with buried sutures of the muscle and skin, covered with gutta-percha tissue and dressed with sterilized gauze.

March 2d.—The wound is dressed. It has healed in the typical way. The patient has no pain and the leg can already be flexed about 45°.

March 23d.—The patient is discharged for misdemeanor.

Example 8.—*Division of the flexor tendons for contracted fingers. Typical healing.*—No. 243. Joseph Hettinger, aet. 28, was admitted to the hospital December 6, 1889. Sixteen months ago the base of the middle finger and the tip of the ring finger of the right hand were crushed by cog wheels. In six weeks the wounds were healed but the injured fingers were strongly flexed.

Examination.—The middle and ring fingers of the right hand are flexed and cannot be straightened. The tip of the middle finger touches the palm of the hand, and the tip of the ring finger rests on the middle finger.

Operation, December 10, 1889.—A triangular flap was made with its apex about opposite the metacarpo-phalangeal joint as in Busch's operation for Dupuytren's contraction. The contraction of the fingers was found to be due to the tendons and not to the fascia. Attempts to straighten the middle finger produced a dislocation forwards of the distal end of the phalanx. The flexor tendons of the middle finger were divided and the finger was straightened. In the gap between the divided ends of the tendons was quite a deep hole. This hole over the metacarpo-phalangeal joint and the base of the first phalanx was allowed to fill with blood. The wound was left wide open and covered with gutta-percha tissue. The finger was bound to a narrow hard rubber splint and dressed with gauze. The tendons of the ring finger were not divided, for the flexion of this finger was believed to be due chiefly to that of the middle finger.

January 6, 1890.—The wound is dressed before the Hospital Medical Society. The blood clot which fills the wound to the level of the skin is almost completely organized. The centre of the blood clot is white, but in the outer zone of this decolorized and opaque portion of the clot may be seen with the naked eye, and more distinctly with the lens, the pinkish gray translucent granulation tissue.

January 20th.—The wound has healed in the typical way. Both the middle and ring fingers are nearly straight. The patient can already flex his middle finger a little. The ring finger he flexes quite well.

Example 9.—*Excision of the supraorbital nerve. No. 105. Primary suppuration of the wound.*—The wound was closed with celloidin. The haemorrhage was not properly checked; and no provision having been made for the escape of the blood, the wound became distended with it and suppurated.

I am quite sure that the suppuration in this case might have been prevented if we had opened the wound enough to relieve the tension of it. We

preferred to run the risk of being compelled to use the case to demonstrate the bad effects of tension in a wound. At one time we would have referred the suppuration to the blood in the wound, and not to the tension.

This is the first closed wound which has suppurated since the opening of the hospital.

EXAMPLE 10.—*Operation for dislocation backwards of the distal row of carpal bones. Suppuration of the wound.*—No. 160. Jas. W. Plummer, aet. 55, was admitted to the hospital October 6, 1890. Seventeen weeks ago he fell from a scaffold and struck on his right palm and hyper-extended wrist. He was treated by a physician for a sprain. For three or four weeks after the accident he suffered great and almost incessant pain. At present the slightest motion of the wrist is painful, and in bad weather the pain is quite constant and severe enough to deprive him of sleep.

Operation, October 7, 1889.—The wrist joint was exposed by two dorsal longitudinal incisions, the one external, the other over the dislocated os magnum. The proximal row of carpal bones was subluxated forwards, far enough to allow the dislocated os magnum to articulate with the radius. The entire distal row of carpal bones was dislocated backwards and rested on the proximal row. The os magnum had been fractured. The entire carpus was excised with the exception of the trapezium and the pisiform bone. The wound was stitched and dressed as usual. For ten days the patient was perfectly comfortable, and his temperature was about normal.

October 17th.—The patient complains of pain in the upper part of his forearm. This is relieved by cutting the bandage a little.

October 20th.—The patient again complains of pain. His temperature is normal. The dressing is removed. The wound is suppurating and the pus has burrowed up the forearm and down under the extensor tendons on the back of the hand. This is the second undrained wound which has suppurated since the opening of the hospital six months ago.

II. OPERATIONS FOR TUBERCULOSIS OF BONES AND JOINTS

Ten cases. Typical healing in all of the cases.

Shoulder: 1 case, No. 356. Elbow: 1 case, No. 318. Hip: 1 case, No. 50. Knee: 3 cases, Nos. 215, 364, 487. Ankle: 4 cases, Nos. 128, 148, 191, 372.

EXAMPLE 1.—*Exsection of the head of the humerus and extirpation of the capsule of the shoulder joint.*—No. 356. John Kalb, aet. 18.

Operation, March 6, 1890.—The shoulder joint was exposed by a long anterior vertical incision. The capsule of the joint was involved in the tuberculous process which had almost perforated it in one or two places. The head of the humerus was removed. In it were three large and many small tuberculous foci. The entire capsule was excised. The scapula was not involved. The cartilage covering its glenoid cavity was perfectly healthy. In closing the wound the skin only was sutured, very loosely and by a few interrupted buried skin sutures placed far apart.

March 17th.—The dressing was removed at a meeting of the Hospital Medical Society. The wound had healed primarily. Here and there between

the sutures were small areas of granulation tissue. At the upper end of the wound could be seen the surface of a small blood clot.

EXAMPLE 2.—*Exsection of the elbow joint.*—No. 318. John Maloney, aet. 17. Admitted to the hospital February 7, 1890. Patient has had a tuberculous elbow for four years. There is now a sinus over the olecranon which communicates with the joint. There are scars of other sinuses which are now closed.

Operation, February 15, 1890.—The olecranon process was circumscribed by a parabolic incision into the joint. From the top of this incision a vertical incision about 5 cm. long was made through the triceps muscle. The sinus was first excised. To do this it was necessary to buttonhole the semicircular flap. The cartilage of the joint had been almost completely destroyed. There were tuberculous foci in the olecranon process of the ulna and in the condyles of the humerus. The diseased bone was removed and the capsule of the joint carefully excised. The skin wound was loosely closed with buried skin sutures of fine black silk. Gutta-percha tissue was placed over the line of the sutures. The dressings were of sterilized gauze. The joint was maintained in position by a plaster of Paris splint.

March 14th.—The dressing was removed at a meeting of the Hospital Medical Society. Through the little circular hole of the semicircular flap projected the well organized blood clot. The wound had healed throughout.

EXAMPLE 3.—*Partial excision of the knee joint.*—No. 215. Mrs. M., aet. 42, was admitted November 13, 1889. She has had tuberculosis of the right knee for several years. Until recently she has been able to walk without crutches.

Operation, November 27, 1889.—The joint was opened by an anterior semi-elliptical incision. It was filled with lenticular "rice" bodies, and a straw-colored gelatinous exudate. The tubercular process had reduced the patella to a shell, and had completely undermined and almost destroyed the cartilage covering the ends of the bones. There was a large tuberculous focus in the head of the tibia. The capsule, the crucial ligaments and the semilunar cartilages were excised. The ends of the bones were shaved with a bone knife, and the tuberculous focus in the head of the tibia incompletely removed by a sharp spoon. The bones were held in position by strong silk sutures. The skin wound was closed by buried skin sutures of fine silk. Gutta-percha tissue was placed over the wound. The limb was enveloped in sterilized gauze dressings. Over all was applied a plaster of Paris splint.

December 2d.—The wound was redressed because the original dressing had become soaked with urine. The wound was perfectly healed.

December 22d.—The dressings were removed and the extremity was put up in a plaster of Paris splint.

May 1st.—There is no sign of a return of the disease. The patient is free from pain and has been walking without crutches for several months.

This case illustrates what I have repeatedly observed, viz., that a tuberculous joint may be perfectly cured even when the diseased tissue has not been thoroughly removed. I am convinced that it is a mistake to suppose that one must thoroughly remove every particle of the tuberculous tissue, in order to arrest the tuberculous process in bones and joints. Surgeons

should not congratulate themselves upon having removed all of the tuberculous tissue whenever there is no return of the disease. It is impossible to determine with the naked eye the limits of the disease. Of this fact any one who carefully controls his operative work with the microscope, may convince himself. I believe it is an accident of rare occurrence for a surgeon to extirpate absolutely every particle of the tuberculous tissue of a joint, and that the permanent cures which so frequently result from operations upon tuberculous joints require an explanation quite as much as the cases of peritonaeal tuberculosis which have been cured by laparotomy require it.

Example 4.—*Excision of the ankle joint.*—No. 372. Harry Smith, aet. 8, was admitted to the hospital March 13, 1890. Patient has a tuberculous left ankle. Behind and a little above the external malleolus is the orifice of a sinus which communicates with the joint.

Operation, March 21, 1890.—The incision which began over the fibula a little above the point at which it becomes subcutaneous was continued along the posterior border of the external malleolus, and around the tip of the malleolus to its termination over the base of the fifth metatarsal bone, external to the insertion of the tendon of the peroneus tertius muscle. The tendons of the peroneus brevis and peroneus longus muscles were divided. The foot was then forcibly extended and supinated and the opposing fasciae and ligaments divided. The supination, extension and adduction were continued until the joint was dislocated. The anterior ligaments were divided from within outwards. The joint was filled with pale and flabby tuberculous granulation tissue. The external malleolus being removed, the lining of the joint was carefully excised. The cartilage covering the lower end of the tibia had been dissected up by the tuberculous process. A small tuberculous focus in the astragalus was chiseled out. Thin lamellae of bone were sawed off from the upper surface of the astragalus and the lower end of the tibia. The divided peronei tendons were sutured. A small counter opening was made at the inner side of the joint to guard against distension of the joint with blood. The wound was loosely closed with buried skin sutures of fine silk, covered with gutta-percha tissue and dressed with sterilized gauze. The ankle and knee joints were immobilized by a plaster of Paris splint.

April 18th.—The dressing is removed. The wound has healed in the typical way. There is a small round granulating spot at the site of the counter opening.

III. Excision of Tuberculous Lymphomata

Ten cases. Seven cervical: Nos. 91, 370, 389, 410, 425, 482, and 490. Two axillary: Nos. 69 and 147. One inguinal: No. 327. Typical healing in all of the cases.

Example 1.—*Excision of cervical glands.*—No. 425. Thomas Skinner, aet. 18, was admitted to the hospital April 17, 1890.

Operation, April 17, 1890.—The principal incision extended from the left mastoid process to the sternum over the sternomastoid muscle. A second incision extended from the left mastoid process, around the angle of the jaw, to the median line of the neck. The triangular flap was reflected and

the anterior fibres of the sternomastoid muscle were divided. The glands were very extensively involved, and many of them were intimately adherent to the tissues surrounding them. Several of the glands were ruptured during the operation and their contents spilled into the wound. The internal jugular vein was stripped quite bare from one end of the wound to the other. The wound was closed with a continuous suture.

April 23d.—The wound is healed and the patient discharged from the hospital.

EXAMPLE 2.—*Excision of axillary glands.*—No. 69. Mary Green, aet. 24, was admitted to the hospital July 29, 1889. For seven years patient has been annoyed with tuberculous cervical glands. These glands have repeatedly inflamed and "burst." At present the patient's neck does not annoy her. There are several large scars in the neck but no sinuses. Four or five months ago the glands of the left axilla began to enlarge. There is now in the left axilla a painful lump about as large as a lemon.

Operation, July 30, 1889.—The axillary glands were extirpated. The wound was closed in the usual way and the fornix of the axilla carefully held up with gauze.

August 6th.—The wound is dressed. It has healed in the typical way.

EXAMPLE 3.—*Excision of inguinal glands and of a tuberculous ulcer of the foot.*—No. 327. Henry S. Young, aet. 18, was admitted to the hospital February 13, 1890. Four years ago the patient was kicked on the outer border of his left foot. The foot swelled, and in a few weeks a sore was established in the skin over the fifth metatarsal bone. After remaining open for two years, the sore became closed for three or four weeks. It then reopened and has been a running sore ever since. Two and a half years ago the glands in the left inguinal region began to enlarge and in a short time they suppurated. About six months ago one or two glands in the left popliteal space inflamed and suppurated.

Examination.—In the skin over the upper and outer surface of the fifth metatarsal bone of the left foot is a sore about 3.5 cm. in diameter which presents the appearances described as characterizing what used to be known as scrofuloderma. The granulations are subcutaneous in parts of the sore. Over the subcutaneous granulations the papillae of the skin are enlarged and covered with thick crusts of epithelium. The edges of the open sore are thin and red and irregularly undermined. The base of the open sore gives the picture of the tuberculous ulcer of the skin. Here and there the granulations are thinly covered with epithelium.

Operations, February 15, 1890.—1. Quite a large piece of tuberculous skin was removed from over the tuberculous inguinal glands. The glands were carefully excised. The wound was allowed to fill with blood: it was then covered with gutta-percha tissue and dressed with sterilized gauze. 2. The ulcer of the foot was excised. The wound was protected with gutta-percha tissue and dressed with sterilized gauze.

February 23d.—The wound of the groin is dressed. It is typically healed. The blood clot is decolorized at its centre and already organized at its edges.

March 5th.—The foot wound is dressed. The blood clot is completely replaced by granulation tissue which is rapidly being covered with epithelium.

IV. Operations for Carcinoma of the Breast

Thirteen cases. Nos. 58, 177, 216, 326, 360, 373, 381, 385, 388, 407, 408, 454, and 489. Typical healing in all of the cases.

Example.—No. 381. Wealthy Mason, aet. 47, was admitted to the hospital March 20, 1890.

About one year ago the patient noticed a lump no larger than a pea just external to the left nipple. The lump has gradually increased in size and is now about as large as a hen's egg. The axillary glands are large enough to be felt.

Operation, March 21, 1890.—The knife was introduced at a point from 3 cm. to 5 cm. below the middle of the clavicle and drawn outwards on to and down the arm to a point a little below the insertion of the pectoralis major muscle. The knife was then reintroduced at the starting point and the tumor circumscribed by a skin incision which gave the diseased tissues at every point a wide berth—a berth of at least 5 cm. Each bleeding point as it presented itself was caught at once by an artery clamp. The tumor, the entire breast and all of the healthy tissues which had been circumscribed by the skin incision were removed in one piece from within outwards, by cutting and tearing, from the ribs and from the fascia which covers the greater pectoral muscle. The triangular skin flap was dissected back to its base. The loose fascia which stretches from the lower border of the free edge of the pectoralis major muscle to the chest wall was torn through with the fingers, the major muscle was raised up from the chest wall and from the pectoralis minor muscle and cut away close to its trunk attachments and at about 5 cm. from its insertion into the humerus. The pectoralis minor muscle was divided transversely at about its middle and drawn upwards so as to completely expose the extreme apex of the axilla under the clavicle. The loose cellular tissue about the first portion of the axillary vein was dissected away with the fingers so as to clearly expose the axillary vein. Starting from this point the tissues were dissected clean from the axillary vessels and nerves, down almost to the lower limit of the skin incision on the arm. Going back again to the apex of the axilla, the axillary contents and with them all the cellular tissue and fat which covers the front and side of the exposed chest wall were dissected off, clean from the ribs. The somewhat wedge-shaped contents of the axilla were thus removed in one piece from the apex to the base or floor of the axilla. The floor of the axilla had already been reflected in the triangular skin flap. The last cutting act of the operation, therefore, was to dissect the base of the wedge-shaped contents of the axilla from the reflected triangular flap of skin.

Two strong silk approximation sutures were taken from the under side of the skin at about 1.5 cm. from its cut margins. These sutures, stretched across the open wound, did not touch the ribs but were suspended in the air about midway between the ribs and the level of the skin. The flap was then pressed up into the axilla to as high a point as possible and was held there by an assistant while its edges were stitched with buried skin sutures to the skin of the chest wall. The open wound was allowed to fill with blood. The approximation sutures became completely buried in the blood clot. The blood clot was protected from the dressing by strips of gutta-percha tissue.

The fornix of the axilla was made as high as possible and its high position was maintained by a wedge of gauze which was held in place by a firmly applied bandage. The inner dressing was of sterilized gauze and the outer dressing of cyprus moss.

April 7th.—The wound is dressed. It has healed in the typical way. The blood clot, which is already almost completely organized, fills the open wound up to the level of the skin. The approximation sutures are buried out of sight in the blood clot. The positions of the approximation sutures are indicated by little convexities of the skin at the margins of the blood clot: *vid.* Plate III, O, O, and ×, ×. A little above the centre of the open wound white spots may be seen in the photograph, and at the lower part of the open wound near its inner edge are some dark spots. The white spots represent the decolorized remains of the blood clot, and the dark spots represent the most deeply pigmented areas of the blood clot. The granulation tissue had reached the surface everywhere except at these light and dark spots. Sometimes at the first dressing the approximation sutures may be seen shimmering through the surface of the blood clot. They soon become entirely concealed by the granulation tissue.

About eight years ago [*1882*] *I began not only to typically clean out the axilla in all cases of cancer of the breast but also to excise in almost every case the pectoralis major muscle, or at least a generous piece of it, and to give the tumor on all sides an exceedingly wide berth.* It is impossible to determine with the naked eye whether or not the disease has extended into the pectoral muscle.

From the careful microscopical examination of many very small cancers of the breast I am convinced that the pectoralis major muscle is usually at the time of the operation involved in the new growth. Strange to say, no authority so far as I know suggests the advisability of always removing the pectoralis muscle or a portion of it in operations for the cure of cancer of the breast; and still stranger there are many surgeons of the first rank—surgeons in favor of methodically cleaning out the axilla—who instead of recommending the excision of the muscle advise the removal of the *fascia* only from the pectoral muscle. König,[12] for example, in the fourth edition of his Surgery says: "When the fascia over the pectoralis muscle is diseased it (the fascia) must be removed." Surely it is absurd not to remove the muscle when its fascia is, even to the naked eye, diseased.

Küster[13] in describing his method says: "Now the breast and with it the fascia pectoralis is detached from below upwards." He adopts Volkmann's technique and apparently accepts his views on the importance of removing the pectoral fascia.

[12] F. König, Lehrbuch der Speciellen Chirurgie, 4 ed., vol. ii, p. 107.
[13] E. Küster, Verhandlungen d. deutsch. Ges. f. Chir., 1883, p. 295.

Volkmann[14] in his Beiträge zur Chirurgie writes as follows:

"I make it a rule never to do a partial amputation for cancer of the breast, but remove the entire breast even for the smallest tumors, and at the same time I take away a liberal piece of skin. The skin defect is, of course, very great when one operates in this manner, and the wound, in consequence, requires a long time for healing. Furthermore, in making the lower incision I cut right down to the pectoralis muscle and clean its fibres as I would for a classroom dissection, carrying the knife parallel with the muscular fasciculi and penetrating into their interstices. The fascia of the muscle is, accordingly, entirely removed. I was led to adopt this procedure because, on microscopic examination, I repeatedly found when I had not expected it that the fascia was already carcinomatous, whereas the muscle was certainly not involved. In such cases a thick layer of apparently healthy fat separated the carcinoma from the pectoral muscle and yet the cancerous growth, in places demonstrable only with the microscope, had shot its roots along the fibrous septa down between the fat lobules and had reached and spread itself out in flat islands in the fascia. It seems to me, therefore, that the fascia serves for a time as a barrier and is able to bring to a halt the spreading growth of the carcinoma."

V. Operations for the Radical Cure of Inguinal Hernia in the Male

Eight cases.[15] Nos. 94, 171, 250, 329, 330, 460, 448, and 481. Typical healing in seven of the cases. In one case, No. 94, the bladder had been included in one or more of the sutures.

Example 1.—No. 339. Henry Smith, negro, aet. 37, was admitted to the hospital February 19, 1890. For two years the patient has had a small right oblique inguinal hernia. At present the hernia is about as large as an orange and is easily reducible.

Operation,[16] *February 20, 1890.*—The skin incision extended from a point about 2 cm. internal to the anterior superior spine of the ilium to the spine of the pubes; *vid.* Plate IV. The subcutaneous tissues were divided so as to expose clearly the aponeurosis of the external oblique muscle, the external abdominal ring and the sac of the hernia. The aponeurosis of the external oblique muscle, the internal oblique and the transversalis muscles and the transversalis fascia were severed to the outer extremity of the skin incision. An incision large enough to admit two fingers was then made into the sac. The index and middle fingers of the left hand, and a small piece of sterilized gauze were passed into the sac. By them the hernial contents were pressed back into the abdominal cavity and over the fingers the sac, first on one side and then on the other, was drawn tense and held by the thumb of the

[14] R. Volkmann, Beiträge zur Chirurgie. Leipzig, 1875, p. 329.

[15] February 17, 1891. I have performed the operation, as described below, for the radical cure of inguinal hernia twenty-one times. In no case, in so far as I have been able to inform myself, has the hernia returned. Last evening, at a meeting of the Hospital Medical Society, eleven of the cases presented themselves for examination. In one case only I did not transplant the cord; in this case the hernia has returned.

[16] *Vid.* The Johns Hopkins Hospital Bulletin, 1889, vol. i, No. 1.

same hand, while the tissues in which the sac was imbedded were stripped off from it by the other hand. With the division of the abdominal muscles and transversalis fascia the so-called neck of the sac vanishes. There is no longer a constriction of the sac. The communication between the sac and the abdominal cavity is more than large enough to admit one's hand. The sac having been completely isolated, was torn more widely open, and the peritonaeal cavity was closed as deeply as possible by seven or eight quilted sutures of fine silk. The sac was then cut away quite close to the line of the peritonaeal sutures. The vas deferens and its vessels having been isolated, they were hooked up into the outer angle of the wound by a quilted suture, which included the transversalis and internal oblique muscles and the aponeurosis of the external oblique muscle. This suture was the first of a row of seven or eight quilted sutures of strong silk, which were passed deeply through the pillars of the ring, and through the divided muscles of the abdominal wall. These sutures were taken very close together, were made to include the deepest tissues available and were tied tight enough to bring into close apposition the broad surfaces which they embraced.

Great care having been taken to ligate every bleeding point, the wound was closed with buried skin sutures of fine black silk. A pad of sterilized gauze about 3 cm. broad and a little longer than the wound was pressed over the line of the skin incision. The skin of the abdomen, thigh and scrotum was carefully dried. The pad was bound firmly in position by a few spica turns of a gauze bandage which had been soaked in absolute alcohol. Finally thin collodion was poured over the entire dressing. In a few moments the dressing was quite hard and the patient was transferred to the stretcher.

March 1st.—The wound is dressed. The wound is perfectly healed. Nothing but the finest linear scar is to be seen; *vid.* Plate IV.

March 6th.—Thirteen days[17] after the operation the patient is allowed to get out of bed and to walk about.

November, 1890.—Nine months after the operation the scar from the operation is scarcely visible. There is no return of the hernia.

Example 2.—No. 94. This is the only case which did not heal in the typical way. John Bleecher, aet. 48, was admitted to the hospital August 15, 1889. Patient has an oblique inguinal hernia on both sides. The hernia on the right side is the larger and has existed for about fifteen years. It has caused him so much pain of late that he desires to be cured of it by operation.

Operation, August 16, 1889.—The operation was done in the way just described. The ring was large enough to admit four fingers.

August 20th.—Patient has not been able since the operation to micturate without great difficulty. It is only by getting on his hands and knees that he has been able to do so. His pulse today is 136, and his temperature is 39.3° C. The dressings are removed. The patient is anaesthetized, and the wound, which looks as if it were healed, is cut open. There escapes from the wound a considerable amount of a very thin, brownish, somewhat blood-stained fluid. The wound is left open.

[17] The patients, as a rule, are not allowed to walk about until the twenty-first day after the operation.

August 24th.—Patient's temperature and pulse are still a little above normal. His dressings were found soaked with urine this morning. The urine certainly reaches the dressings by way of the wound, and hence it is probable that the wall of the bladder was caught by one or more of the deep sutures.

September 8th.—Three days ago the patient voided some of his urine in the natural way, but until today the greater part of the patient's urine has escaped through the wound.

September 10th.—There has been no urine on the dressings since the last note.

November, 1890.—The patient made a perfect recovery, and up to date, 15 months after the operation, has had no return of his hernia.

VI. Amputations of the Thigh

Two cases. Nos. 313 and 364. Typical healing in both cases.

Example.—*Amputation of the thigh at the lower part of its upper third for sarcoma of the knee-joint.*—No. 313. W. B. Griffen, aet. 22.

Operation, April 26, 1890.—Neither the tourniquet nor the Esmarch bandage was made use of. The vessels were tied as they were encountered and before they were divided. The patient did not lose more than one or two ounces of blood. The patient was in a bad condition for the operation. But the loss of blood was so little that his pulse was about as strong after the operation as it was before it. A circular and two lateral incisions were made through the skin. The rectangular flaps were dissected back about 6 cm. The vessels were divided separately. The muscles and skin flaps were intentionally made quite short. Long flaps are of course unnecessary when a wound unites by first intention. The muscles were brought together quite loosely by fine silk buried sutures. No attempt was made to obliterate the rather large dead space between the sawed end of the bone and the muscles. The danger of strangulating tissue in the effort to obliterate this dead space is so great that I prefer to allow a blood clot to occupy it. The smaller dead spaces were ignored. The skin flaps were trimmed short and their edges were brought together gently by buried skin sutures of fine silk. These sutures were placed about 3.5 cm. apart. Abundant opportunity was thus afforded for the escape of blood. The skin wound was covered with gutta-percha tissue. The dressing was of sterilized gauze. The stump was flexed at right angles to the trunk and held in place by a plaster of Paris bandage.

May 5th.—Nine days after the operation, the dressing was removed at a meeting of The Johns Hopkins Hospital Medical Society. The wound had healed throughout by first intention.

VII. Arthrodesis for Paralytic Flail-Joint

Five cases. Nos. 178, 322, 348, 416, 444. Typical healing in all of the cases.

Example.—No. 348. Mollie Morris, aet. 17, was admitted to the hospital February 26, 1890. She had an attack of infantile paralysis when she was two years old. Her right ankle is now a flail-joint. She brings her foot to the ground in an extreme valgus position. Her foot pains her almost con-

tinuously whether she uses it or not. The pain is very great when she attempts to walk.

Operation.—The joint was opened by an anterior transverse incision. Everything encountered except the anterior tibial vessels and nerve was divided. The articular surfaces and with them thin discs of the tibia, fibula and astragalus were removed. The tibia and astragalus were held together by strong silk sutures. The skin wound was united by buried skin sutures, covered with gutta-percha tissue and dressed with sterilized gauze.

March 1st.—The dressing is removed in order that a close fitting plaster of Paris splint may be applied. The wound is perfectly healed.

April 4th.—The plaster splint is removed. There is firm union between the tibia and the astragalus.

October, 1890.—The position of the foot is still good and the patient walks well and without pain.

VIII. Trendelenberg-Hahn Operation for the Cure of Acquired Flat Foot

Two cases. Nos. 334 and 466. Typical healing in both cases.

Example.—No. 466. Charles Brown, aet. 15, was admitted to the hospital May 20, 1890. About one year ago patient's left foot began suddenly to give him pain when he walked. The foot became swollen, and when the swelling had disappeared the patient noticed that one of the "ankle bones" was projecting.

Examination.—The patient's foot pronates when he walks. He walks upon the inner side of his foot. He has a typical flat foot.

Operation, May 21, 1890.—The tibia was chiseled through a little above the ankle joint as advised by Trendelenberg and Hahn. As it was still impossible to bring the foot into a strong varus position, a wedge-shaped piece of bone was removed from the tibia. Without much force the foot could then be brought into a satisfactory position. The skin wound was stitched with buried skin sutures, covered with gutta-percha tissue and dressed with sterilized gauze. The varus position was maintained by a plaster of Paris splint.

June 1, 1890.—The wound is dressed. It has healed primarily. A close fitting plaster of Paris splint is applied.

IX. Operations for Ununited Fractures

Two cases. Typical healing in both cases.
Humerus: 1 case. No. 419. Femur: 1 case. No. 449.

Example.—No. 449. I. A. Dorsey, aet. 54, was admitted to the hospital May 2, 1890. In October, 1889, the patient sustained a simple fracture of the right femur. He was treated for seven weeks with a Smith's anterior splint, and has not been able to walk since the accident.

Examination.—The right thigh is 7.5 cm. shorter than the left. There is an ununited fracture of the right femur at a point a little above its middle. The upper fragment is abducted and rotated outwards. Its lower end is sharp and pointed, and has almost perforated the skin.

Operation, May 7, 1890.—The inflamed skin over the lower end of the upper fragment was excised. A longitudinal incision, about 15 cm. long, was made on the outer side of the thigh. From the middle of this incision and at right angles to it a transverse incision, about 5 cm. long, was carried towards the back of the thigh. The ends of the fragments were so greatly atrophied and overlapped so much, that it was thought advisable to remove 4 cm. from the upper and 3 cm. from the lower fragment. The bones were drilled and fastened together by strong silk. The skin wound was stitched with buried skin sutures and covered with gutta-percha tissue.

No attempt was made to obliterate by buried sutures the dead spaces of the wound. The dressings were of sterilized gauze and cyprus moss. The thigh was immobilized in a plaster of Paris splint.

May 31st.—The wound is examined. It has healed primarily. There is as yet no evidence of bony union.

X. Operations for Fractures of the Patella

Two cases. Nos. 247, 362. Typical healing in both cases.

Example.—No. 247. Robert Sommering, aet. 41, was admitted to the hospital December 10, 1889. A few hours before admission the patient tripped over a car track, and in falling "felt both knee caps break" before they touched the ground.

December 11th.—The right knee was put up in an apparatus by Dr. Brockway, the house surgeon.

Operation, December 13th.—A transverse incision was made into the left knee-joint between the fragments. The upper fragment did not comprise quite the whole of the upper third of the patella. This fragment was tilted in such a manner that its fractured surface looked almost directly upwards as the patient lay upon his back. All the tissues from the skin down to the bone had slipped in between the fragments; so that to bring the fragments accurately together without an operation would have been impossible. The tissues interposed between the broken surfaces were cut away and the fragments were accurately brought together by sutures which did not pass through the bone. The skin wound was united by buried skin sutures, covered by gutta-percha tissue and dressed with sterilized gauze.

December 17th.—The wound is dressed. It has healed primarily. The left leg is put up in a plaster of Paris splint. Between the fragments of the unsutured patella is a gap of about 1.5 cm.

June, 1890.—Patient has had another fall and has torn the ligamentous union which existed between the fragments of the patella which was not sutured. He has already almost perfect motion of the left knee. The left patella is apparently perfect. A few days after the readmission of the patient, Dr. Brockway, the house surgeon, sutured the fragments of the right patella.

XI. Osteotomy for Bow-Legs

Three cases. Nos. 236, 336, 410. Typical healing in all of the cases.

Example.—No. 410. Richard Schmidt, aet. 7, was admitted to the hospital April 9, 1890. His parents state that his legs began to bend when he

was two years old. The bowing has increased steadily from that time to this. The boy has now well marked anterior curvature and very exaggerated lateral curvature of both legs.

Operation, April 10, 1890.—Both legs were operated upon. Transverse skin incisions were made opposite the apices of the lateral curves. The tibiae were divided with the osteotome. The fibulae were broken by hand. The skin wounds were united by buried skin sutures, covered with gutta-percha tissue and dressed with gauze. The legs were immobilized in plaster of Paris dressings.

April 27th.—The dressings are removed. The wounds are perfectly healed. There is already considerable bony union of both tibiae. The slight deformity which still remains is corrected and the legs reencased in plaster of Paris.

May 22d.—Patient's legs are firm and quite straight. He is allowed to walk.

XII. Incision and Irrigation of Joints for Gonorrhoeal Arthritis

Three cases. No. 77, knee; No. 104, ankle; No. 172, wrist. Typical healing in all of the cases.

Example.—No. 77. John Schlenck, aet. 57. Admitted to hospital August 2, 1889. Patient has gonorrhoea. His right knee and left ankle joints are distended with fluid and are very painful. There is considerable oedema of the right leg and of the left foot.

Operation, August 3, 1889.—An incision about 10 cm. long was made along the inner edge of the patella and into the joint. The joint was distended with a blood-stained, sero-purulent exudate. The fluid was evacuated and the joint irrigated for twenty minutes with a solution of corrosive sublimate (1-50,000). Two or three interrupted silk stitches were taken in the capsule of the joint. The muscle wound was not sutured. The skin wound was stitched with buried sutures of fine silk and covered with gutta-percha tissue. The knee was dressed with sterilized gauze and fixed in an extended position.

August 14th.—The dressings are removed. The wound is healed. There is no fluid in the joint, but flexion of the joint is quite painful.

September 20th.—The patient can flex his knee joint perfectly and without pain. We have made several attempts to cultivate on human blood serum the gonococcus from the exudate of gonorrhoeal joints, but without success. In one instance we found, beyond a doubt, the gonococcus in the fluid from a knee joint. In every case we have made the usual test tube inoculations for pyogenic microorganisms and in no case did a single colony develop.

XIII. Extirpation of Inguinal Glands for Gonorrhoeal Adenitis

Six cases. Nos. 344, 358, 392, 397, 432. Typical healing in five of the cases.

In the unsuccessful case, No. 344, the original dressing was removed a few days after the operation at a meeting of the Hospital Medical Society.

The wound had healed primarily but the blood clot did not completely fill the uncovered dead space over the saphenous opening. The wound had probably been investigated by the fingers of members of the society and hastily redressed. At the second dressing the blood clot was found to have broken down and there was pus at the bottom of the dead space.

Example.—*Double inguinal bubo.*—No. 358. John B——, aet. 20, was admitted to the hospital March 5, 1890. The skin over the glands of the right groin is not inflamed. An incision had already been made into the glands of the left groin.

Operation, March 6, 1890.—An elliptical piece of skin which included the old incision was removed from over the glands of the left groin. Irregular T-shaped incisions were made in both groins and the glands thoroughly extirpated on both sides. Several of the softened glands burst during the operation and evacuated their contents into the wounds. It seemed advisable, therefore, to irrigate both wounds for several minutes with a solution of corrosive sublimate, 1-1000. The wounds were sewed with buried skin sutures. At the bottom of each wound, over the saphenous opening, was a rather large dead space. On the left side the dead space could not be covered by skin. These spaces were allowed to fill with blood. The wounds were covered with gutta-percha tissue and dressed with gauze.

March 14th.—The wounds are redressed. Both wounds have healed primarily. There is a small granulating wound on the left side which represents the organized blood clot.

XIV. Operations for Syphilis of Bones

Two cases. Nos. 67 and 451. Typical healing in both cases.

Example 1.—*Operation for gumma of the external condyle of the humerus.*—No. 67. Ida Carson, aet. 9, negress. Admitted to the hospital July 29, 1889. Patient has hereditary syphilis. Her corneae are opaque, her teeth are serrated. The external condyle of the left humerus is enlarged and sensitive to pressure.

Operation, August 1, 1889.—The external condyle was freely exposed by a long longitudinal incision and explored with the chisel. The surface of the exposed bone was rough and had a worm-eaten look. At about 1 cm. from the surface was a mass of necrotic tissue about the size of a large filbert. This tissue was removed and the walls of the cavity were shaved with a sharp spoon. The bone cavity was allowed to fill with a blood clot. The skin was loosely stitched with buried silk sutures. The skin wound was covered with gutta-percha tissue. The hand, forearm and arm were enveloped in a sterilized gauze dressing. The elbow was fixed in an extended position by a plaster of Paris bandage.

September 10th.—Forty-one days after the operation, the dressing is removed for the first time. The wound is completely healed. There is perfect motion of the elbow joint. Before the operation, the elbow could not be completely extended.

Example 2.—*Operation for syphilitic periostitis of a rib.*—No. 451. Moses Conway, aet. 23, negro. Admitted to the hospital May 5, 1890.

Patient has gummata of the skull, lower jaw and rib. About 5 cm. below and 1 cm. external to the left nipple is a small fluctuating tumor. The long diameter of the swelling is parallel to that of the ribs in this situation.

Operation, May 7, 1890.—An incision, about 10 cm. long, was made into the tumor. Its soft necrotic contents were evacuated and a rib, eroded and deprived of its periosteum, was exposed. The eroded portion was removed, the walls of the cavity excised and the wound irrigated with a solution of corrosive sublimate, 1-1000. The wound was loosely closed with buried skin sutures of fine silk, covered with gutta-percha tissue and dressed with sterilized gauze.

May 10th.—The wound is dressed. It has healed primarily.

XV. Necrotomies and Operations for Bone Abscesses

Eleven cases. Complete organization of the blood clot and typical healing in eight cases: Nos. 142, 244, 325, 335, 366, 423, 430, and 437. Incomplete organization of the blood clot in two cases: Nos. 340 and 352. Complete disintegration of the blood clot in one case: No. 265.

Example 1.—*Sequestrotomy for osteomyelitis of the tibia.*—No. 437. Richard Kelly, aet. 20, was admitted to the hospital April 19, 1890. Patient had an acute osteomyelitis of his right humerus when he was three years old, and of his right tibia when he was five years old. Both bones have been operated upon repeatedly. The sinuses of the arm and leg have healed, but there is now a large abscess over the middle of the tibia. The skin over this abscess is inflamed and very thin.

Operation, April 23, 1890.—A longitudinal incision about 18 cm. long was made over the tibia. The front wall of the involucrum was chiseled away. The remains of the sequestrum were removed, and the granulations lining the involucrum were most carefully scraped away. The bone cavity was thoroughly painted with pure carbolic acid. The soft walls of the abscess were excised and the entire wound was freely washed with a corrosive sublimate solution, 1-1000, and then with a carbolic acid solution, 1-20. The wound was incompletely closed by a few buried sutures. It was then allowed to fill with blood and was covered with strips of gutta-percha tissue. Moist corrosive sublimate gauze was applied next to the gutta-percha tissue, and over all a huge dressing of sterilized gauze. The knee and ankle-joints were immobilized by a plaster of Paris splint.

May 5th.—The dressing is removed before the Hospital Medical Society. The blood clot is organized throughout and the wound is reduced to a small granulating sore.

Example 2.—*Sequestrotomy for osteomyelitis of the humerus.*—No. 423. Hermann Wunderloh, aet. 13, was admitted to the hospital April 15, 1890. About one year ago the patient's left humerus was attacked with acute osteomyelitis. About one week after the onset of the attack an abscess appeared on the antero-internal surface of the upper part of his left arm and was lanced by the attending physician. Since then several abscesses have formed about the humerus. From all of these abscesses pieces of bone have from time to time been discharged. With the exception of one sinus at the

upper part of the antero-internal surface of the arm all the sinuses are now closed.

Operation, April 17, 1890.—An incision about 22 cm. long was made from one end of the humerus to the other over its antero-internal surface. The front wall of the involucrum was freely chiseled away and two sequestra removed—one from near the upper and one from near the lower end of the humerus. The granulations lining the involucrum were carefully scraped away. The gutter-shaped cavity was thoroughly cauterized with pure carbolic acid. The wound was irrigated freely with a corrosive sublimate solution, 1-1000, and then with a carbolic acid solution, 1-20. The skin wound was loosely closed by buried skin sutures, allowed to fill with blood, covered with gutta-percha tissue and dressed with gauze.

May 5th.—The dressing is removed before the Hospital Medical Society. The wound is perfectly healed.

The cases in which there was partial or complete disintegration of the blood clot—cases 340, 352 and 265—were particularly instructive ones to us. In case 340, the wound was completely filled with granulation tissue on the thirtieth day after the operation; in case 352, on the fifteenth day, and in case 265, on the twenty-sixth day.

The rapid filling of these large bone cavities, notwithstanding the fact that their blood clots had become disintegrated is, I think, to be ascribed to the treatment of the wounds. The slow filling of such cavities, when treated by the usual methods, must likewise be ascribed to the treatment. For such wounds are usually stuffed with gauze. In ten days or two weeks, the stuffing is removed, and with it the granulations which have grown into it. Then the wound is restuffed. In a few days the stuffing is again pulled out and the young granulations are again demolished. This treatment is often continued for months, and under it the granulation tissue becomes converted into dense fibrous tissue, poorly supplied with blood vessels and unable to produce anything but the feeblest granulations which finally become more or less completely covered with epithelium. And so it happens that these large bone cavities frequently do not become filled and do not heal and remain a ghastly reproach to the surgeon.

A bone cavity should never be stuffed. The granulations should be encouraged to grow as luxuriantly as possible. Whether the blood clot melts away or not, the bone cavity should be bridged over by skin or by protective or gutta-percha tissue. The granulations must be most carefully protected from insult. They should rarely if ever be irrigated. In other words, a bone cavity which has lost its blood clot, should be treated as if it still possessed it. If, after a few weeks, the cavity is not filling rapidly it should be cauterized with pure carbolic acid, its granulations should be made to bleed sufficiently to fill the cavity with blood and the wound should be given the opportunity to heal under the secondary blood clot. Suppurating wounds

of soft parts should be treated in the same way. They should not be stuffed. The granulations of open sores should be protected from the dressing by gutta-percha tissue or something of this sort. In the out-patient department of the hospital opportunities are afforded us nearly every day to observe the astonishingly rapid healing of wounds which are treated in this way. For example, a patient with scalp wounds two or three weeks old presents himself. There is considerable oedema of the scalp and the wounds which are inflamed are found stuffed with iodoformized gauze. We remove the stuffing, cauterize the wounds thoroughly with pure carbolic acid, bridge them over with gutta-percha tissue and put on a gauze dressing thick enough to protect them. If we examine the wounds within 24 hours, we find that they are filled with a more or less clear and solidified wound secretion. Within 72 hours and perhaps within 48 hours, the "secretion clot," so-called by us, is completely organized and the inflammation and oedema of the scalp have disappeared.

Example 3.—From the wards. A boy was operated upon by some one for an ununited fracture of the bones of the leg. The wound suppurated.

About two months after the operation the boy was consigned to us with a wound that was suppurating freely and which was stuffed with iodoformized gauze. We made two longitudinal incisions into the wound, removed the wire sutures, scraped away with the utmost care the granulation tissue which lined the suppurating wound and sawed off a thin piece of bone from each of the fragments. The wound was then cauterized with pure carbolic acid and loosely closed by buried skin sutures. In a few days the wound was healed.

XVI. Extirpation of Varicose Veins of the Leg and Thigh

Four cases. Nos. 262, 279, 296 and 328. Typical healing in all of the cases.

Example.—No. 254. Charles H. Gaupner, aet. 48 years, has for about twenty years been annoyed by varicose veins of both thighs and legs. On admission, January 2, 1890, patient states that the pains in his legs are severe enough to incapacitate him from work.

Examination.—The long and short saphenous veins and their tributaries are dilated, thickened and very tortuous. There is oedema of the left leg.

Operation on the veins of the left leg, January 10th.—An incision about 60 cm. long was made over the internal saphenous vein—the incision extended from about the junction of the lower and middle thirds of the thigh to the internal malleolus. The veins were in places (back of the internal condyle of the femur and behind the malleolus) adherent to the skin. This necessitated the making of skin flaps from the under-surface of which the veins were cut away. The internal saphenous vein was excised from one end of the incision to the other. The skin was stripped back for about two inches on both sides of the incision and the underlying veins were dissected

out. The wound was closed with a continuous suture of fine black silk. No attempt was made to obliterate the dead spaces. The line of suture was covered with strips of gutta-percha tissue. The dressings were of sterilized gauze. These were not applied tight enough to interfere with the circulation in the skin, the vitality of which is impaired in operations for the removal of varicose veins: the dead spaces were, consequently, allowed to fill with blood.

January 17th.—The wound is dressed. There is primary union throughout. The little flap behind the knee has sloughed at its edge.

January 30th.—The little slough has become organized. Its place is occupied by granulation tissue. The patient has had no pain since the operation.

XVII. Operations for the Removal of Cysts and New Growths

Fourteen cases. Nos. 82, 217, 238, 320, 354, 376, 382, 431, 433, 440, 442, 446, 471, and 491. Typical healing in all of the cases.

Example 1.—*Osteoma of the scapula.*—No. 440. Mildred Calstron, aet. 18, was admitted to the hospital April 29, 1890.

Operation, April 30, 1890.—The tumor, about the size of a hen's egg, was removed from the infraspinous fossa near the axillary border of the scapula. The wound was loosely closed with buried sutures and the dead space allowed to fill with blood. The dead space was undoubtedly considerably obliterated by the pressure of the dressing.

May 6th.—The wound is dressed. It has healed primarily.

Example 2.—*Syphilitic testicle.*—No. 446. John H., aet. 31, was admitted to the hospital May 1, 1890.

Operation, May 3, 1890.—Amputation of the testicle. The wound was closed with buried sutures.

May 8th.—The wound is dressed. It has healed primarily.

Example 3.—*Lipoma of the wall of the thorax.*—No. 369. Martha Moore, aet. 40.

Operation, March 13, 1890.—Removed a flat, round lipoma about 9 cm. in diameter from the wall of the thorax. The tumor which was situated below the left breast on the prolongation of the anterior axillary line was bisected, and each half removed from within outwards. I believe this to be the easiest way to remove lipomata, cysts and other benign tumors. The wound was closed with buried skin sutures, covered with gutta-percha tissue and dressed with sterilized gauze.

March 19th.—The dressing is removed. The wound is typically healed. There is a very small decolorized blood clot at the inner angle of the wound.

All of the eleven cases of group XV were actively suppurating ones at the time of operation. In eight of these cases there was complete and typical organization of the blood clot; in two of them the organization of the blood clot was incomplete, and in one case there was complete disintegration of the blood clot.

If we exclude the cases of this group there remain 111 cases, 108 of which healed in the typical way. There was suppuration in two cases and haemorrhage in one case; *vid.* group I. From October, 1889, to June, 1890, all of the cases healed in the typical way.

Of the wounds which heal primarily probably the majority do so, notwithstanding the presence of microorganisms. Success in the treatment of wounds does not depend alone upon the exclusion of pyogenic microorganisms from the wounds for the following reasons:

1. There is not, I believe, a technique which from a bacteriological point of view may be considered perfect.

2. Test tube inoculations made by us a few days after the operations from the surface of the new cicatrix, from the fine line of granulations, from the surface of the blood clot, from the tip of the gauze plug and from the bottom of the sinus occupied by the plug[18] frequently yielded a number of colonies of pyogenic organisms.

3. Injections of virulent cultures of *Staphylococcus aureus* into the tissues and into the peritonaeal cavity were not followed by suppuration nor by peritonitis.

4. Operations upon bone abscesses, the walls of which it is, perhaps, never possible to thoroughly disinfect, and upon suppurating wounds of the soft parts which likewise cannot be thoroughly disinfected were usually attended by perfect organization of the blood clot.

5. Many wounds heal primarily when no antiseptic precautions whatever have been taken.

6. The majority of subcutaneous wounds in preantiseptic times were not followed by suppuration.

7. The wounds of most surgeons heal as a rule primarily up to the drainage tubes.

Ad. 1. From the numerous experiments which we made about one year ago on disinfection of the skin we conclude that it is impossible to thoroughly disinfect it by any of the methods which have hitherto been recommended, and that it would at least consume much time to do so even occasionally by any of the means at our disposal.

In some instances we have subjected the skin to a rigorous disinfection for four days. Then test-tube inoculations were made from scrapings of the skin over the part to be operated upon. In every case we have had the dissatisfaction of finding at least three or four colonies in each of the inoculated tubes. *Staphylococcus aureus* was one of the prevailing organisms.

[18] It was not until the fall of 1889 that, for clean wounds, we discarded, absolutely, drainage in all of its forms. Since September, 1890, we have closed, without drainage, *all* wounds—the suppurating as well as the clean wounds.

Profound constitutional effects have sometimes followed the not very prolonged [from 10 to 12 hours] application to the skin of carbolic solutions as weak as 1-60.

We have made many experiments on the disinfection of the hands. On several occasions forty-five minutes were devoted to the disinfection of one pair of hands and without success. Within the past few months Dr. Roose, one of my assistants, and Dr. Ghriskey, one of Dr. Kelly's assistants, have continued the experiments on hand disinfection under the supervision of Dr. A. C. Abbott and confirm our work of last year. The work of all who have written on the subject of hand disinfection has probably been characterized by one and the same fault. The scrapings from under the nails and from other places which have been used for test tube inoculations were perhaps saturated with the solution used for disinfection or at least contained enough of the disinfectant to inhibit the growth of microorganisms. We found that hands which had been soaked in a corrosive sublimate solution [1-1000] and were then washed with two litres of sterilized water still became quite black when immersed in a solution of ammonium sulphide. In all of our experiments, therefore, we have profited by the work of Geppert[19] and have precipitated the mercury before making the test tube inoculations. Hands which have been besmeared with a fluid culture of some microorganism can undoubtedly be so disinfected or washed so clean of the given microorganism, that no colonies of it will develop in the finger prints on a Petri's plate, and the nails of three or four fingers may in ten or fifteen minutes be so well attended to, that scrapings from the specially prepared places may be sterile. But to disinfect absolutely all parts of both hands is a different problem and one that has not been solved. In not a single instance have we succeeded in disinfecting the hands. The nearest approach to a perfect disinfection was made by the operating room nurse. On one occasion, when she had devoted nearly one hour to her hands, scrapings were made from four places. Four Esmarch tubes were made with these scrapings. Three of the tubes remained sterile. In the fourth tube there was one colony of a long slender bacillus. Ordinarily from three to six and sometimes many more colonies appeared in each of the tubes inoculated with scrapings from hands which had been disinfected for 45 minutes. We believe that it is possible to disinfect the hands and hope that others may be stimulated by our results to investigate the subject of hand and skin disinfection afresh and with other disinfectants.

If it were possible to sterilize the hands of the operator and his assistants and the skin of the patient, the surgical technique might be made a practically perfect one. The danger of infection from the air is probably a theo-

[19] Geppert, Berliner klin. Wochenschr. Nos. 37 and 38, 1889.

retical and not a real danger. We have exposed for hours large Petri's plates—ten or twelve at a time—to the air of the operating room before, during and after operations and have never found a single colony of pyogenic microorganisms.

Ad. 2. Having assured ourselves of the fact that our technique was necessarily imperfect we became much interested in the test tube inoculations made from the surface of wounds which had healed throughout by first intention and from the bottom of sinuses occupied by the small gauze drains of wounds which had healed without suppuration. These inoculations were made at the first dressing. Not more than one-half of the tubes remained sterile. It was interesting to observe that the sinuses which at the first dressing furnished pyogenic microorganisms were often found to be perfectly healed at the second dressing. The tearing of the granulations by the withdrawal of the gauze plugs provided many of the sinuses with blood clots which became organized notwithstanding the presence of the pus-producing germs. The organization of the exudates which filled the other sinuses took place as perfectly as did that of the blood clots.

Ad. 3. We experimented[20] almost exclusively with *Staphylococcus aureus,* and always with cultures the virulence of which we had determined by inoculations into the ear veins of rabbits.

Inoculations of the Peritonaeal Cavity with Pure Cultures of *Staphylococcus aureus*

The peritonaeal cavity was, in each instance, opened by an incision three or four cm. long through the linea alba. The wounds were closed by two rows of buried sutures and dressed with celloidin.

Group I. 2 dogs. Experiment. A small piece of potato covered with a thick growth of *Staphylococcus aureus* [culture No. 1] was introduced into the peritonaeal cavity. Both dogs died of general peritonitis.

Group II. 13 dogs. Experiment. One c. cm. of a bouillon culture of *Staphylococcus aureus* [culture No. 1] was introduced into the peritonaeal cavity. Peritonitis did not develop in a single case.

Group III. 10 dogs. Experiment. One c. cm. of a bouillon culture of *Staphylococcus aureus* [culture No. 2] was introduced into the peritonaeal cavity. Peritonitis did not develop in a single case.

Group IV. 5 dogs. Experiment. A small piece of sterilized potato was introduced into the peritonaeal cavity. Peritonitis did not develop in a single case. The pieces of potato were usually found adherent to the great omentum and covered by a transparent and almost invisible film of connective tissue.

[20] Our bacteriological experiments were made in the Pathological Laboratory of The Johns Hopkins University.

Group V. 7 dogs. Experiment. A small piece of potato covered with a thick growth of *Staphylococcus aureus* [culture No. 2] was introduced into the peritonaeal cavity. All of the dogs died of general peritonitis.

Group VI. 8 dogs. Experiment. A small piece of omentum was ligated with strong silk. The ligature and the tied off portion of the omentum were inoculated with a drop or two of a bouillon culture of *Staphylococcus aureus*. There was fatal peritonitis in two cases, and circumscribed peritonitis in two cases. Four of the dogs recovered without peritonitis.

Injections of Pure Cultures of *Staphylococcus aureus* into the Muscles

Group I. 2 dogs. Experiment. Ligated the left femoral vein and artery about two cm. below Poupart's ligament and injected one c. cm. of a bouillon culture of *Staphylococcus aureus* into the muscles of the left leg. Within twenty-four hours there were oedema of the left leg and induration and tenderness at the seat of injection. Within three days the oedema had disappeared. Within a week the local tenderness and induration had also disappeared. In neither case did an abscess develop.

Group II. 7 dogs. Experiment. Ligated the right femoral artery and injected one c. cm. of a bouillon culture of *Staphylococcus aureus* into the muscles of the right leg. Within twenty-four hours there were in all cases a hard swelling and tenderness at the seat of injection. In no case was there oedema of the right leg, and in no case did an abscess develop.

Group III. 6 dogs. Experiment. Ligated the left femoral vein and injected one c. cm. of a bouillon culture of *Staphylococcus aureus* into the muscles of the left leg. In all of the cases there supervened an oedema of the left leg and a local tenderness and swelling at the seat of the injection. In no case did an abscess develop.

Injections of the Exudate of a Purulent Peritonitis into the Skin

Two dogs. Three c. cm. were injected *into* the skin over the knees of both dogs. Only a slight reaction followed the injections.

Ad. 4. It is our practice now to treat without drainage not only clean wounds, but also almost every suppurating wound. The walls of old abscesses and sinuses are excised or, when excision is impracticable, scraped. The cutting and scraping must be done conscientiously and with great patience. The Esmarch bandage is of service in these operations. Irrigations, which we have abolished for clean wounds, may be used freely in these suppurating cases before the Esmarch bandage is removed. The suppurating wounds are carefully painted with pure carbolic acid, loosely stitched with interrupted buried skin sutures and covered with gutta-percha tissue. There is often considerable dead space in the wounds made for the cure of many and long old sinuses. The dead spaces become filled with blood after the operation. The inflamed skin surrounding the orifices of the old sinuses having been cut away, the provision for the escape of the blood

from such wounds is usually more than sufficient. The dressings are very large and loosely applied. If the wound is between two joints it is well to immobilize both of these joints. I believe that it is particularly important to prevent a breaking up of the blood clot in suppurating cases. The technique in these cases is necessarily far from perfect. The wounds, nevertheless, heal as a rule in the typical way. We must conclude that we are indebted to the tissues as well as to the antiseptics for our good results.

Ad. 5. Wounds of parts which are rich in blood vessels usually heal by first intention even when no antiseptic precautions have been taken. Operations on the face and perineum are notably successful. The pyogenic microorganisms succumb to tissues in which the circulation is so active.

Ad. 6. The majority of subcutaneous wounds of preantiseptic times were surely infected. Subcutaneous wounds were made with knives which had never been disinfected and which perhaps for years had been used to incise abscesses. But the subcutaneous wounds rarely suppurated. Open wounds, on the other hand, suppurated with great regularity. If an open wound were to be distinguished from a closed wound merely by the length of the incision, we might accept the generally received explanations for the suppuration of the former. I believe that the immediate cause of the suppuration is usually the rough manipulation of the infected tissues and the strangulation of the tissues by infected ligatures and sutures.

Ad. 7. Few surgeons now-a-days have a technique bad enough to prevent the union of raw surfaces which have a good circulation, if the dead spaces have been thoroughly drained and if the tissues have not been constricted by ligatures and sutures.

THE TREATMENT OF WOUNDS.

The Management of the Dead Spaces

Whether a surgeon disinfects by carbolic acid, corrosive sublimate or by steam; whether he uses catgut or silk for his sutures and ligatures; what material he uses for his dressings; whether the dressings are simply sterilized by heat or impregnated with antiseptics, are matters of minor importance to the patient.

Of great consequence is *The Management of the Dead Spaces in Wounds.* These may be obliterated, drained or allowed to fill with blood.

The more imperfect the technique of a surgeon the greater the necessity for drainage. The most rigid antiseptic precautions are demanded for the obliteration treatment of dead spaces: the buried sutures employed to obliterate the dead spaces necessarily enfeeble the circulation and impair the vitality of tissues which otherwise might be able to dispose of large quantities of microorganisms.

It is doubtful if one ever obliterates absolutely the dead spaces of a wound: and certainly most undrained wounds contain small blood clots however patient and conscientious and skillful the attempts at obliteration may have been. Upon the organization of small blood clots, therefore, depends more or less the healing of all undrained wounds.

But the unintended blood clot of an incompletely obliterated dead space is, I think, much more likely to decompose than the intended blood clot because it—the former—lies in tissues the circulation of which has been interfered with by buried sutures, and in a wound which is particularly exposed to the dangers of strangulation and tension.

The blood clot treatment of dead spaces has the following advantages:

1. Tissue defects are beautifully repaired.[21]
2. Obliteration sutures are dispensed with.

Sutures and Ligatures

I believe that the obstruction to the circulation produced by sutures and ligatures is often the immediate cause of suppuration in infected wounds, and that the larger the masses of tissue constricted and the tighter the strangulation the greater the danger of suppuration. The complete strangulation of large masses of tissue we try to avoid by using very weak silk for the sutures and ligatures.

The occasional breaking of the silk reminds one that he is tying with too much force or that he has included too much tissue in his ligature. We use the finest black sewing silk—Nos. 00, 0 and A. For large arteries we sometimes double the fine silk, and for deep sutures we often use the coarser numbers. Inasmuch as we cannot disinfect the skin thoroughly, we never perforate the skin with a suture. The skin wound is invariably closed by "buried skin sutures." These sutures are taken from the under-surface of the skin. They are fully described in the Bulletin of The Johns Hopkins Hospital.[22]

We consider these sutures an important contribution to the technique of surgery. The wounds are not exposed to the suppuration which so often

[21] Experiment upon a dog. We removed a piece of the triceps muscle and trephined the external condyle of the humerus. The wound was allowed to fill with blood and was covered with gutta-percha tissue. No stitches were taken. The extremity was immobilized in a plaster of Paris splint. In three weeks the plaster was removed. The defect in the bone was so perfectly repaired that it was impossible to see with the naked eye a line of demarcation between the old tissue and the new.

[22] These stitches do not perforate the skin, and when tied they become buried. They are taken from the under side of the skin, and made to include only its deep layers—the layers which are not occupied by sebaceous follicles. Johns Hopkins Hospital Bulletin, vol. i, p. 13.

has its origin from the sutures of the skin. It is not necessary to remove the buried skin sutures. In from three weeks to two months they appear on the surface as little loops and may be brushed away. If the sutures are well applied the scars may be almost invisible. In Plate IV such a scar is represented.

The manipulation of the ligatures is a weak point in the technique of almost every surgeon. The ligatures are often cut before the operation and allowed to hang over the edge of the dish in which they are arranged; or they are brought in contact with something as they are passed from the instrument table to the operator; and even in the hands of the operator the ligatures are still in danger of becoming infected. When fifty ligatures, more or less, are used at an operation it may be ascribable to good luck if all of the ligatures escape infection. We conclude from our experiments that the infection of a wound from ligatures and sutures is more likely to

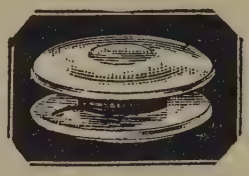


Fig. 9.

be followed by suppuration than are the infections from other sources. The chances of accidental infection from ligatures are diminished by the employment of glass spools [23] such as are represented in Fig. 9 and Plate I, 1.

A spool wound with about 2 meters of silk is held in the left hand and is unwound with the right hand of the operator as he ligates the vessels.

The sterilization and preservation of the silk is with us a very simple matter. Six or eight spools armed with silk are placed in a test tube (*vid.* Plate I, 1) and sterilized by steam. Before the operation the spools are poured from the test tubes into a dish containing a solution of carbolic acid, 1-30. One of the advantages of preparing silk as we prepare it is that it may be kept sterile permanently without losing its strength. If fine silk be disinfected and preserved in any of the usual ways it soon becomes so weak as to be worthless.

The Dressings

Between our wounds and the dressings we interpose strips of gutta-percha tissue to protect the granulations. The tearing off of a dressing into which

[23] These glass spools were made for me by Messrs. Warmbrunn, Quilitz and Co., No. 40 Rosenthalerstrasse, Berlin. They may now be obtained from Messrs. Eimer and Amend, New York.

the granulations have grown is a barbarous act which insults both the wound and the patient. Even wounds which we wish to keep open or to tampon we protect by the gutta-percha tissue. We have found this tissue of great service in the treatment of ulcers. Until we adopted the plan of protecting every wound in this way I did not know how very seriously the cicatrization of wounds was retarded by the usual treatment of them. Gauze and tree moss are the materials which we use for our dressings. They are sterilized by steam in the Arnold steam cookers. These cookers are very convenient and satisfactory sterilizers. They are so cheap that a hospital can afford to have many of them. To each dressing we assign a cooker. When a dressing is required the cooker containing it is brought into the operating room and placed on a tripod at a convenient distance from the operating table.

The Disinfection of the Hands

The best results were obtained when water as hot as could be endured was employed in all of the acts of the disinfection. One of my assistants could soak his hands in water at 49° C. The average hand can be held in water at 47° C. without much discomfort. We have adopted the following rules for the disinfection of our hands.

1. Scrub the hands and forearms for about ten minutes with the officinal green soap in water as hot as possible. 2. Wash off the soap in three or four basins of water as hot as possible. 3. Clean the nails most scrupulously with a sharp steel instrument. 4. Soak the hands and forearms for ten minutes in a hot corrosive sublimate solution, 1-1000. This proceeding is too severe to be employed every day. It is advisable, therefore, to so group one's cases that the "clean" ones shall be operated upon only on certain days—two days, perhaps, in one week.

The Preparation of the Patient

About 18 hours before the operation the part to be operated upon is shaved if necessary and covered with a huge poultice of green soap. Three hours before the operation the soap is thoroughly washed off in a bath of hot water and the skin of the patient is vigorously scrubbed. An astonishing amount of desiccated epithelium is scrubbed off with the soap.[24] A large wet gauze dressing is then applied. This dressing is then irrigated from time to time for an hour with a solution of carbolic acid, 1-30, and thereafter up to the time of the operation with a solution of corrosive sublimate, 1-1000. On the operating table the part to be operated upon is scrubbed

[24] We are indebted to one of the resident surgeons of the Roosevelt Hospital, New York, for suggesting this application of the soft soap.

and washed for a few minutes with a hot solution of corrosive sublimate, 1-1000.

The Operation

The operator and two of his assistants are protected from the bystanders by the semicircular instrument table (*vid.* Fig. 10). The assistant who passes the instruments wears thin rubber gloves which are disinfected in a corrosive sublimate solution. The only hands which come in contact with the wound are those of the operator. The sponging is done by the operating

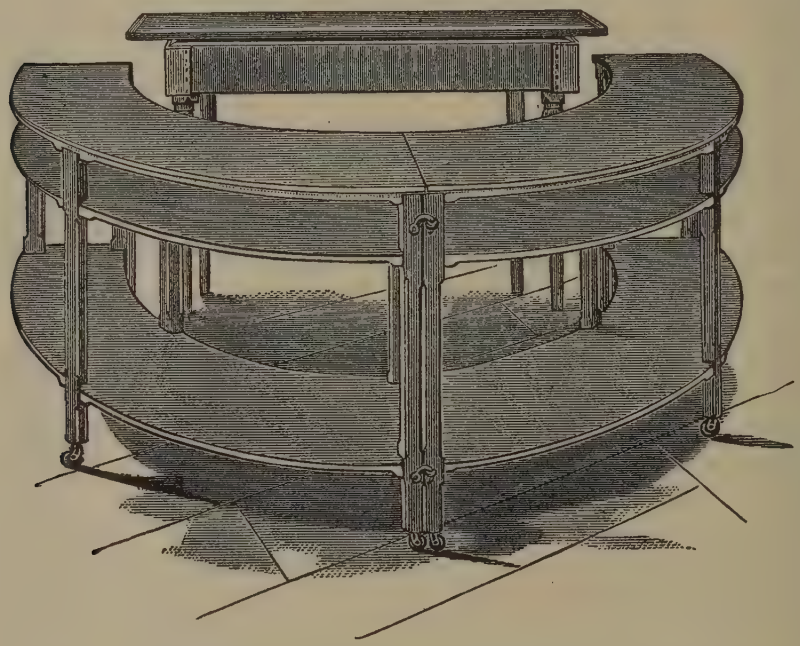


Fig. 10.—The Semicircular Instrument Table and the Operating Table.

room nurse who wrings dry the sponges, one at a time, as they are required. The pieces of gauze used for sponging are kept in a solution of corrosive sublimate, 1-1000. We consider it unsafe to use sponges which have been sterilized simply by steam unless the top of the sterilizer be removed and replaced each time that a sponge is required. It surely is not safe to expose on a table or in a basin the dry sterilized sponges to the many dangers of infection from contact.

Irrigation is employed only in suppurating cases. We have ascertained from our experiments on dogs that irrigation with solutions of corrosive sublimate as weak as 1-10,000 produces a superficial necrosis. Wounds which have been freely irrigated with solutions of corrosive sublimate not

stronger than 1-5000, or moderately irrigated with solutions as strong as 1-1000, do not unite throughout by first intention. The wound in the skin unites and the divided ends of the muscles unite, but the skin is separated from the muscles by a thin serous or serofibrinous exudate. The cavity which contains this exudate is lined by a film of necrotic tissue thick enough to be seen with the naked eye. Little cavities filled with the same exudate are found occasionally in the connective tissue planes between the muscles.

The tissues are handled very delicately in operating. We avoid, if possible, the tearing of the tissues, and the strangulation of the tissues by ligatures and sutures. Large dead spaces are sometimes partially obliterated by buried sutures: as a rule the dead spaces are allowed to take care of themselves. The wound is closed with interrupted buried skin sutures so placed as to preclude the danger of distention. The dressing is so applied that it shall exert a gentle, even pressure. I have said that "I conceive an ideal wound to be one which immediately after the operation is reduced to the condition of a non-penetrating, subcutaneous wound, and which is as free as this is from the dangers of infection. A wound which has been irrigated with solutions of carbolic acid, corrosive sublimate or other disinfectants labors under the disadvantage of a more or less extensive area of superficial necrosis from which the subcutaneous wound is free. The subcutaneous wound is not exposed to the dangers which attend the introduction of drainage tubes, ligatures and sutures, nor to the greatest of all dangers for the surgeon's wound, that of infection from the hands of the operator and his assistants."

We have reduced our wounds almost to the condition of non-penetrating, subcutaneous wounds. They are neither irrigated nor drained. The chief danger from sutures is eliminated by the employment of the buried skin sutures. The strangulation of the tissues is to a great extent avoided by care in the application of the ligatures and sutures and by the use of very fine silk. The hands of the surgeon are, as a rule, the only hands which touch the wound, and these are disinfected in the manner described. The instruments are passed by the gloved hands of a trustworthy assistant; and the sponging is done by a well-trained, operating room nurse who takes them, one by one, as they are required, from the corrosive sublimate solution. I am under great obligations to Dr. A. C. Abbott for instructing in bacteriology the operating room nurse and all of my assistants, and for supervising and taking the keenest interest in our bacteriological work. All of the preparations for the operations—the recrystallization and weighing of the corrosive sublimate for the solutions, the selection and sterilization of the instruments, the preparation and sterilization of the silk and the dressings, the final disinfection of the patient—were intrusted to the operating room nurse.

The Operating Room

The floors, shelves and tables of the operating room are impregnated with paraffine. For the tables and shelves the paraffine is melted and rubbed in with a hot iron. For the floor the paraffine is dissolved in turpentine and painted on with a brush.

The Operating Table

The patients are anaesthetized on long, narrow boards. They are then arranged for the operation, strapped to their boards and transferred with

Fig. 11.—The Operating Table.

them to the top of a shallow sink on four legs. This sink is about 20 cm. wider and 45 cm. shorter than the board (*vid.* Fig. 11). By shifting the board the side gutters can at any moment be made as wide as may be desired. For operations on the head and feet the board is shifted in a longitudinal direction, far enough to make a gutter at the head or foot as well as at the sides of the board. The end of the board which falls within the end of the sink is supported on a small loose block which is placed on the floor of the sink. The floor of the sink drains to a hole in its centre.

The perineal board (*vid.* Fig. 12), is about 18 cm. shorter than the sink. The height of the patient's buttocks is regulated by the shoulder yoke. By pushing the yoke up the inclined plane the perineum of the patient can be

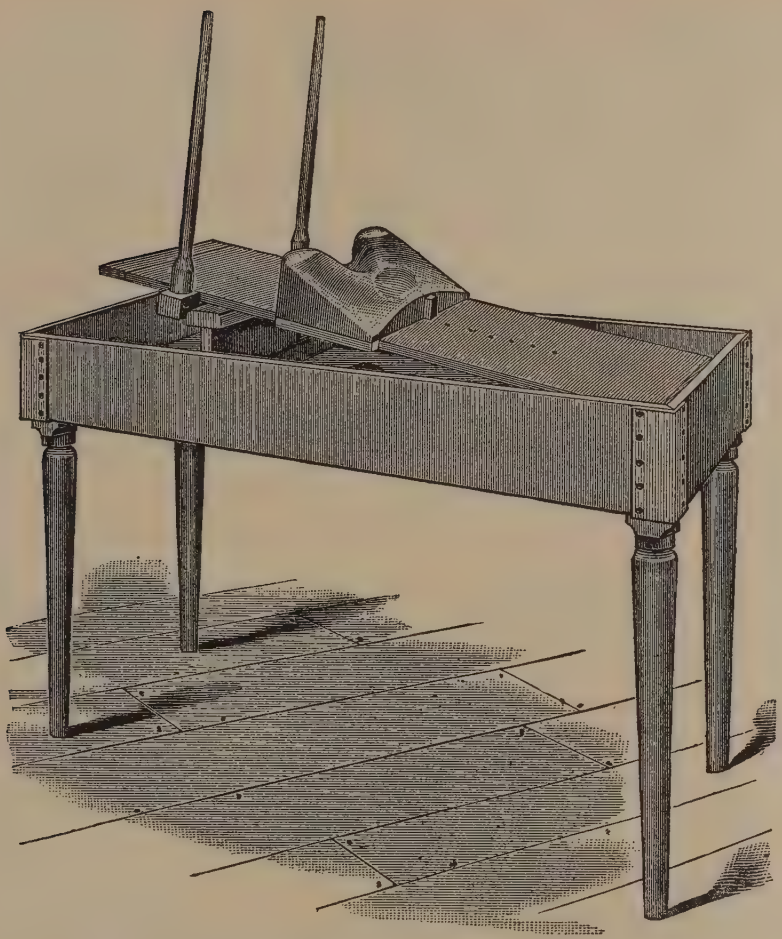


FIG. 12.—The Operating Table with its Perineal Board.

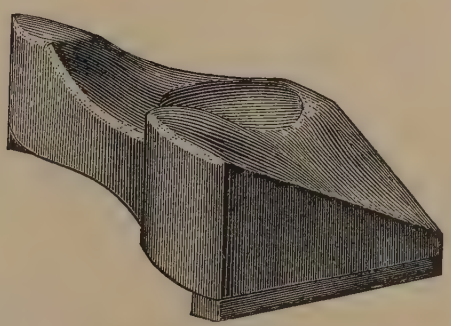


FIG. 13.—The Yoke of the Perineal Board.

raised to the level of the standing operator's eyes and the patient's back be exposed up to the shoulders. The yoke (*vid.* Figs. 12 and 13), is made from a solid block of ash, and is carved to receive comfortably the head, neck and shoulders of the patient. The patient's legs are flexed and bear, behind the knees, against the vertical posts.

The posts of the perineal board are made of hickory. The table and all of its parts are made of ash and should be thoroughly paraffined six or more times in the first year.

DESCRIPTION OF THE PLATES.

PLATE III.—The wound as it appears at the first dressing after an operation for the removal of carcinoma of the breast.

The open wound is completely filled with a blood clot.

The little convexities, O, O, and ×, ×, of the skin at the margin of the clot are caused by the approximation sutures which are buried in the clot. The white spots at the upper part of the open wound represent the decolorized parts of the blood clot. The dark spots at and near the inner edge of the open wound represent deeply pigmented areas of the blood clot.

This case illustrates well the use which is made of the triangular flap to cover the defect. The apex of the flap was originally about 2.5 cm. below the centre of the clavicle. It is now almost on the line of the nipples.

PLATE IV.—The wound as it appeared at the first dressing after an operation for the radical cure of inguinal hernia. The wound extended from + to +.

It was closed with buried skin sutures.

PLATE IV

CRUSH OF ELBOW—ORGANIZATION OF BLOOD CLOT[1]

The second patient you will recognize as one whom I presented to you last winter to illustrate the organization of a very large blood clot. His left elbow had been run over by one or more wheels of a horse car, about thirty minutes before admission to the hospital. The injury sustained was about as great as is possible in such an accident. The elbow felt like a bag of bones. The skin was broken in three places, and was very badly contused on the arm and forearm, as well as about the elbow. At the operation, the existing wounds were enlarged, and lacerated pieces of the triceps muscle, fragments of the lower end of the humerus and the olecranon process of the ulna were removed. Three or four longitudinal incisions were made through the skin, which was undermined in all directions. The oozing of blood, which was considerable, was purposely not checked. The wound was allowed to fill with blood. No stitches were taken. The arm, elbow, and the upper part of the forearm were wrapped with strips of protective about one inch wide. The usual dressing of sterilized gauze was applied and the arm was fixed in an extended position. I exhibited the elbow to you at the second dressing when the granulations had just reached the surface of the blood clot in some places.

It is now seven months since the operation. The patient has a perfect joint, as you may see. He can flex, extend, pronate and supinate about as well as he ever could. I consider this to be one of the best blood clot cases that we have had. The clot must have been as large as a man's fist.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, October 20, 1890.

Johns Hopkins Hosp. Bull., Balt., 1890, i, 111-112.

PLASTIC OPERATION FOR THE OBLITERATION OF A LARGE CAVITY IN THE LOWER END OF THE FEMUR[1]

W. L. Coddington, aet. 30, was admitted to the hospital September 15, 1891. Twenty years ago, and shortly after a fall upon the right knee, the patient suffered from an acute, circumscribed osteomyelitis of the lower end of the right femur. The pus quickly made its way through the skin a little above the inner condyle of the femur. A year later a small piece of bone was discharged through this opening in the skin. Fifteen years ago the skin on the outer side of the thigh a little above the knee joint was perforated and through this second opening several pieces of bone escaped. The patient has within the past two or three years been twice operated upon by well-known surgeons. On admission the lower end of the right femur is much enlarged. The soft parts above the joint are thick and hard and perforated in three places, in front, above the internal condyle and above the external condyle. Through each of the openings the probe enters the cavity in the lower end of the femur.

Operation, September 17, 1891.—A long anterior, longitudinal incision through the common extensor muscle and an internal, longitudinal incision were made. Through these incisions the front and inner walls of the cavity were so cut away that the soft parts could fall into the cavity and almost obliterate the dead space. The bony wall was cleaned with a spoon and freshened with a gouge and the walls of the three sinuses were excised. The dead spaces of the wound were allowed to fill with blood. The wound was covered with gutta-percha tissue and dressed as usual.

The wound, as you may see, has healed in the typical way. In this case as in the preceding one the bony wall of the cavity was very hard and unable to furnish vigorous granulations. Two surgeons, as I have said, operated upon the case without success. It seemed inadvisable therefore to repeat their work. *An unsuccessful surgical operation upon such a cavity is an injurious surgical interference. For to each scraping the bony wall responds with a feebler crop of granulations.* A plastic operation of some sort was clearly a necessity in this case, and the plan of treatment which we adopted promises to be a satisfactory one.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, October 5, 1891.

Johns Hopkins Hosp. Bull., Balt., 1891, ii, 160-161.

A SUPPURATING, COMPOUND, COMMINUTED FRACTURE INTO THE ANKLE JOINT TREATED WITHOUT DRAINAGE[1]

William Clark, aet. 16, was admitted to the hospital September 29, 1891. A day or two before admission, while attempting to board a freight train, he slipped and caught his left foot, he does not know how, in the gear of the car and sustained a compound fracture of both malleoli. On admission the boy was suffering greatly. His temperature was 39.4° C., his pulse 132. The left foot, ankle and leg were much swollen. There was an angry blush about the ankle which extended downwards to the toes and upwards to the middle of the leg. Over the inner malleolus was a transverse wound about 6 cm. long through which projected the lower inner edge of the shaft (the upper fragment) of the broken tibia. Both malleoli were broken square off. There was some comminution of the inner malleolus and of the lower end of the tibia. The joint was suppurating.

Operation.—The ankle joint was fully exposed by the usual external lateral incision. Through this incision the cartilage was sawed off from the tibia, the astragalus exsected and the cartilage chiseled away from upper surface of the os calcis. A longitudinal incision into the joint was then made from the inner side. Through this incision the fragments of the internal malleolus and of the tibia were extruded. A few additional longitudinal incisions were made through the tissues which were particularly tense. Then a slow but vigorous massage was practised for some minutes to relieve the tissues of the great tension which existed. I was surprised at the rapidity with which the serum escaped through the cuts and at the amount of the transudate. In a few minutes the swelling of the foot, leg and ankle was dissipated. Had it not been for these long and numerous cuts we should have been obliged to remove the Esmarch bandage before practising the massage. The propriety of exercising massage in such a case without the Esmarch bandage might be questioned. The Esmarch was removed temporarily to enable us to ligate the larger vessels. It was then replaced for the final disinfection of the wound; the leg was placed in a bath of corrosive sublimate (1-1000) for about three minutes, and then in a bath of carbolic acid (1-20) for about three minutes. No stitches were taken. The wounds were covered with gutta-percha tissue and the dressing applied before the Esmarch bandage was removed.

The patient's temperature declined rapidly to the normal point. He has not had an unfavorable symptom since the operation.

The wound is dressed tonight for the first time since the operation. You will observe that there is no redness nor swelling of the limb.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, October 5, 1891.

Johns Hopkins Hosp. Bull., Balt., 1891, ii, 160-161.

The blood clots are more or less completely organized. The clot which fills the ankle joint is breaking down on the surface; but in a week or ten days the granulations will everywhere be even with the surface. This method of treating such cases is surely preferable to that which stuffs the dead spaces with gauze or drainage tubes. I would emphasize the following points in the treatment of cases like this one:

1. Excise cartilaginous surfaces and thus avoid having dead walls for dead spaces.

2. Make free antitension incisions to relieve tension and to enable one to practise massage protected by the Esmarch bandage.

3. Remove the Esmarch bandage temporarily to ligate the principal vessels.

4. Use as few and as fine ligatures as possible. Avoid tight and unnecessary stitches.

5. Disinfect the limb, protected by the Esmarch bandage, just before applying the dressing.

6. Apply the dressing before the final removal of the Esmarch bandage.

THE SURGERY OF FOREIGN BODIES

REMOVAL OF FOREIGN BODIES[1]

I. A PIECE OF FIBRO-CARTILAGE REMOVED FROM THE OESOPHAGUS BY EXTERNAL OESOPHAGOTOMY.

II. THREE CALCULI, EACH WITH A PORTION OF A SOFT CATHETER AS A NUCLEUS, REMOVED FROM THE BLADDER BY LATERAL LITHOTOMY AT ONE OPERATION.

III. A PORTION OF A BULLET REMOVED FROM THE DIPLOË AND CRANIAL CAVITY.

CASE I.—*A piece of fibro-cartilage removed from the oesophagus by external oesophagotomy.*—At Ward's Island, July 23, 1882, a Hungarian, aged thirty-three, swallowed at dinner a piece of food which became arrested in his oesophagus a little below the cricoid cartilage. The resident physicians were unsuccessful in their attempts to dislodge it. They obtained, however, a fragment which, submitted to microscopical examination, proved to be fibro-cartilage. The patient was said to have experienced great difficulty in breathing for several hours, and then to have become quite tolerant of the foreign body, but to have been unable to swallow even liquids.

July 25th.—The foreign body, indistinctly definable by palpation of the neck, was believed to be lodged in the oesophagus, just above the sternum, projecting more to the right side than to the left. An incision, extending from the middle of the thyroid cartilage to the interclavicular notch of the sternum, was made parallel with the anterior border of the sternocleidomastoid muscle. The oblique jugular vein was drawn toward the median line. The middle thyroid vein in the upper angle of the wound was doubly ligated and divided. The common carotid artery, crossed by the omohyoid muscle, rolled up into view. The foreign body was readily mapped out through the oesophageal walls, and over it was stretched the recurrent laryngeal nerve. An incision an inch and a quarter long was made into the oesophagus, parallel with and posterior to the nerve, and the foreign body, measuring $1\frac{1}{2} \times 1 \times 1$ inch, was removed with a vulsella. The wound in the oesophagus was united by sulphurous acid catgut, and the integument by silk sutures. An iodoformized peat dressing was applied. A few days later the patient was clandestinely served with blackberries by missionaries to the island, which interfered with union by first intention, but otherwise did not hinder his prompt recovery.

CASE II.—*Three calculi, each with a portion of a soft catheter as a nucleus, removed from the bladder by lateral lithotomy at one operation.*—The patient, a Finn, about thirty-five years old, had been in the habit of

[1] Presented at the New York Surgical Society, January 22, 1884.
N. York M. J., 1884, xxxix, 226-227.
Also: Med. News, Phila., 1884, xliv, 201.

evacuating his paralyzed bladder with a soft catheter. One day the catheter broke off in his bladder, and a piece, believed to be two or three inches long, was left behind.

He subsequently regained the power of his bladder, and applied, six or eight months after the mishap, at Ward's Island, for relief of frequent and painful micturition. A stone was detected by Thompson's searcher. In consideration of the history, it was believed to be advisable to practise the cutting operation. The patient had such a short perinaeum that the finger, introduced into the bladder, could ascertain the number and shape of the stones. These were carefully seized with the forceps in such a way as not to be crushed, and removed.

The patient's convalescence was somewhat protracted because of a cystitis perpetuated by a few fragments, which he eventually passed *per urethram*.

Each calculus contained a piece of the catheter, its point being distinctly visible in one of them.

Case III.—*A portion of a bullet removed from the diploë and cranial cavity.*—Mr. H. U. G., aged fifty-two, was admitted to the Chambers Street Hospital, May 9, 1883, for a self-inflicted pistol-shot wound of the head.

A small circular scalp wound was found on the right side, two inches and a half below the sagittal suture and one inch in front of the external auditory meatus. The reflexes were normal, and there was no paralysis; the intellect was perfectly clear.

A crucial incision was made through the scalp. The external table was found depressed, and at the bottom of the depression there was a hole one-quarter of an inch in diameter and about one inch behind the bullet wound in the soft parts. A probe, passed obliquely backward through the hole, detected the foreign body, which was not visible.

Thereupon certain fragments of the external table were removed, and the bullet was revealed, lying between the two tables, and projecting somewhat into the cranial cavity. Upon its extraction, a slightly depressed fragment of the inner table was withdrawn.

The wound was dressed antiseptically, and closed with a continuous catgut suture. Union took place by first intention throughout, except where the incisions crossed one another—viz., at the point of entrance of the bullet—and here there was a very slight necrosis of the approximated corners of the flaps.

The bullet had split upon the outer table of the parietal bone; one fragment entered the diploë and cranial cavity, as described, and the other passed through a mirror and was found behind the bureau.

SUCCESSFUL REMOVAL OF LARGE FOREIGN BODY FROM THE HEAD[1]

To the Editor of The Philadelphia Medical Journal:

In connection with the interesting case published by Dr. Tiffany of the removal of a chisel from a man's head, the following notes from memory of a similar case upon which I operated years ago, may be of interest:

"A man, about 40 years old, consulted me in 1882 or 1883 seeking to be relieved of chronic nasal catarrh, nasal voice and, I think, headache. Examination of the nose resulted in the discovery of a piece of metal very firmly engaged in the nose and imbedded apparently in the body of the axis. The patient was as much surprised at the findings as I was, and rejoiced at being able to confront his medical advisers with evidence which sustained his opinion, frequently expressed to them, that an explosion more than five years before had in some way caused his troubles. He had been, perhaps for an instant, slightly shocked by this explosion, but had felt no pain and knew that he had been injured only when blood began to trickle down his face and into his mouth. The surgeon in charge discovered a transverse wound of the skin covering the bridge of the nose, which he promptly stitched, securing union by first intention. I found a fine linear scar in the skin just below the articulation between the frontal and nasal bones, and a slight deformity of the bridge of the nose. A few days after the first visit of the patient I removed by an osteoplastic operation through cheek and nose an irregularly shaped piece of steel almost as large as a dental plate for the upper jaw."

It was only after exercising a great amount of force that I was able to dislodge this piece of steel which had been imbedded for so many years, and I know that at the time I considered the operation a hard one, and was proud of the result. A short handle-like projection, bent about at right angles to the rest of the plate, was held in a way to make extraction of the entire piece particularly difficult. Contemplating the plate of steel after its removal, we were astonished to learn that such a large foreign body could have passed through a wound so short as that indicated by the scar, and have caused so little deformity; for the nasal bones, and, I think, one at least of the nasal processes of the superior maxilla, must have been fractured. The man recovered promptly from the operation.

[1] A letter to the Editor of the Philadelphia Medical Journal.
Phila. M. J., 1900, v, 4. (Reprinted.)

A CONTRIBUTION TO THE SURGERY OF FOREIGN BODIES[1]

I. STELLATE CALCULI IN FORM RESEMBLING JACKSTONES REMOVED FROM THE BLADDER BY SUPRAPUBIC LITHOTOMY.
II. TWO HUNDRED AND EIGHT FOREIGN BODIES AND SEVENTY-FOUR GRAMMES OF GLASS EXTRACTED FROM THE STOMACH BY GASTROTOMY. RECOVERY.

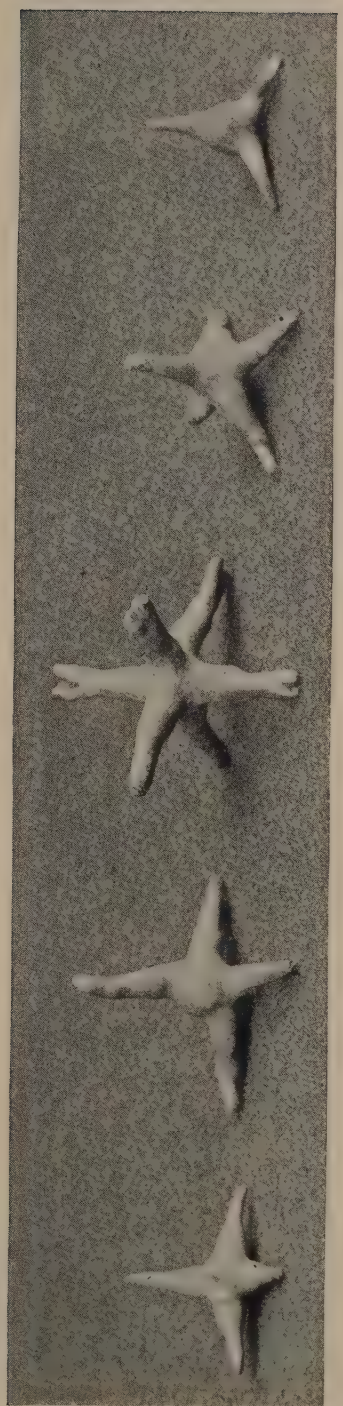
I.—*Large stellate, "jackstone calculi" removed from the bladder by suprapubic cystotomy.*—B. G., aet. 84, was admitted to The Johns Hopkins Hospital December 9, 1891. The patient was too feeble to give a clear history of his case. He believed that until about a year ago he had had no bladder symptoms. At this time, he had, as he called it, a severe attack lasting about one month, characterized by painful and difficult micturition. Patient regained his health, he stated, and could get about quite as well as before, except that he could not ride horseback; the jolting of riding produced pain in his perinaeum and a desire to urinate. He remained well until the present attack, which began about six weeks before admission and was almost precisely like the first one. He now micturates two or three times an hour or oftener, passing from 10 c. c. to 50 c. c at a time.

Examination.—Patient is emaciated; his mucous membranes are pale; his arteries tortuous and rigid; he has a conspicuous arcus senilis; his bladder is distended to within 4 cm. of the umbilicus; the meatus urinarius is very small; the prostate is very large.

Urine.—Specific gravity 1010; albumin; reaction alkaline; much sediment. *In sediment:* epithelial cells, a few red corpuscles, amorphous urates and numerous triple phosphate crystals. It was considered inadvisable to explore the bladder with an instrument before operation because of the patient's very feeble condition.

Operation, December 11, 1891. Suprapubic cystotomy.—An incision into the bladder large enough to admit two fingers was made, and five calculi were extracted with the fingers (see Plate V). These calculi were lying free in the pouch behind the prostate. They were very light in weight and light grayish-brown in color. The largest calculus, the one first extracted, resembled so strikingly the ordinary jackstone that the five stones have always been referred to as *jackstone calculi.* The perfect one has six prongs of about equal length, joining a small hub at the centre; these prongs are so inserted into the hub that each one is at right angles to all of the others, except the one which is in a direct line with it. Each prong is bifid at its tip. The smaller stones are less perfect, but they appear to be all of the same type.

[1] Prepared for "Contributions to the Science of Medicine, dedicated by his Pupils to William Henry Welch upon the Twenty-Fifth Anniversary of his Doctorate."
Johns Hopkins Hosp. Rep., Balt., 1900, ix, 1047-1059. (Reprinted.)



Vesical Calculi Removed December 1, 1891, by Supra-public Cystotomy. (Exact size.)

Last summer I was greatly pleased to discover in the Hunterian Museum of the Royal College of Surgeons, London, two sets of minute calculi resembling closely those which I have just described. There are twelve in one set, and fifteen in the other. All of the stones in the Museum of the Royal College are much smaller than mine and were obtained post mortem from the kidney. My largest stone measures 3½ cm. in its longest diameter and is almost perfectly symmetrical. Oliver T. Duke, Esq., presented, in 1868, the set of fifteen to the Museum of the Royal College of Surgery. This set is labeled *C 78* in the museum catalogue. The second set, presented by J. McCarthy, Esq., is labeled *C 144* in the catalogue of the museum, and before presentation was described by him in the Medico-Chirurgical Transactions, published by the Royal Medical and Chirurgical Society of London, Vol. LV, 1872, p. 263. Mr. McCarthy furnishes a plate of the stones and the result of the analysis of one of them. Unfortunately our *jackstone calculi* were so carefully laid away by some one before a chemical analysis had been made that we cannot find them. Inasmuch as the Medico-Chirurgical Transactions are accessible to so few of us, and Mr. McCarthy's brief description of his calculi is so admirable and interesting, I shall quote what he says:

"In February, 1872, a woman was admitted into the London Hospital under the care of Mr. Couper for spontaneous fracture of the neck of the left femur, the result of cancer, which, originating in the uterus, had spread through the sacrosciatic foramina and involved the soft structures round the left hip with the upper part of the left femur. She was moribund when admitted and there was nothing to attract attention especially to her kidneys, any pain that she complained of being naturally referred to the disease of the uterus.

"She died soon after her admission, and on making the post-mortem examination I found the upper part of the pelvis filled with a cancerous mass which pressed upon, and obliterated her left ureter; on removing the left kidney and making a section in the usual manner, I found the pelvis enormously distended, the medullary portion almost altogether absorbed, and the cortical substance the seat of acute suppurative nephritis. The upper part of the left ureter was occupied by a large conical mulberry calculus and the distended pelvis contained eleven calculi; the remarkable shape of which induces me to bring them under the notice of your society.

"The calculi all felt soft and greasy when first removed from the kidney and some greatly resembled biliary calculi. The projections on the surface of the large calculus were unusually acuminated, and the rest consisted of a central globular body with four or five prominent spines. In five the central mass was about the size of a black currant, and the spines were short and stunted. In the remaining six the central part was smaller and the spines longer and more tapering. Three had a very symmetrical tripod base with a single erect central spine. The other three had much the same general outline but with one or more additional and shorter spines. The pelvis

of the right kidney contained a single oblong spiculated calculus which has been analyzed for me by Dr. Tidy, assistant to the Lecturer on Chemistry at the London Hospital Medical College. The results of his analysis are as follows:

Moisture	9.55 per cent.
Oxalates	8.72 "
Lithates	34.8 "
Chlorine	3.22 "
Sulphuric acid	4.56 "
Phosphates	a trace.
Fat and Cholesterine	36.56 per cent.
Loss	2.59 "
	100.00 "

"Mr. Curling has kindly informed me that there is a somewhat similar specimen of renal calculi in the museum of the Royal College of Surgeons. They are much smaller, with very fine and delicate spines. They are numbered *C 78* in the catalogue and are described as being composed of oxalate of lime. They were found in the kidney of a patient in whom the only noticeable feature during life was albuminuria. I cannot offer any explanation of the unusual shape of these calculi, which appear to be too symmetrical to have been formed accidentally."

I, too, am at a loss for an explanation of the form of these calculi, and, with Mr. McCarthy, agree that something more than accident is responsible for their symmetry. I did not extract them from pockets in the bladder wall. We were not permitted to make an autopsy upon our patient, who became delirious almost immediately after the operation, had suppression of urine, and died on the seventh day.

In the Hunterian Museum these calculi are labeled and known as the oxalate of lime calculi. It is greatly to be regretted that an examination of our calculi could not have been made; but I still believe that some day they will be found.

II.—*Two hundred and eight foreign bodies and 74 grammes of glass extracted from the stomach by gastrotomy. Recovery.*—A. S., aet. 21, carpenter, was admitted to the medical side of The Johns Hopkins Hospital on Wednesday March 14, 1900. The patient had been making his living by swallowing, or pretending to swallow, glass, tacks, etc. His present illness dates from Saturday, March 10th, when he was stripped by some medical students and challenged to swallow articles in their presence to convince them that he was an honorable man and not a fake. He began his demonstration at 7 p. m. Saturday and did not satisfy his diabolical inquisitors until 2 o'clock Sunday morning. About 2.45 a. m. on Sunday he vomited dark fluid, but none of the ingested foreign bodies. After vomiting, he experienced a sharp, piercing pain in the epigastric region and back. He

has attempted to take his food regularly, although vomiting followed each meal. The distress has been constant, and exacerbations of pain are often severe. Patient could not sleep on Sunday night, and on attempting to start to work on Monday morning, he suddenly vomited. Altogether he vomited twice on Monday, twice on Tuesday, and once on Wednesday morning; the last vomitus was very green. At no time have there been foreign bodies in the vomitus. Loose greenish stools on Sunday, Monday and Tuesday contained none of the ingested bodies.

March 14th.—Patient had a chill yesterday morning followed by fever. He complains today of very severe pain in the abdomen, particularly in the epigastrium. At times he rolls himself about in bed in paroxysms of pain. The abdomen is quite flat but very rigid. The respiratory movements are greatly restricted. All of the abdominal muscles are very rigid, but nothing further is made out on palpation.

In the skiagraph taken just before the operation, the stomach is sharply defined, as if the viscus was filled with a shadow-casting mass; but gentle palpation, even under ether, did not reveal the outlines of this mass. The reason for this undoubtedly was that the foreign bodies occupying chiefly the deepest part of the fundus of the stomach anchored it in such a position that it could not readily be palpated, and at least could not be distinguished clearly from the vertebral column and the ribs.

March 15th, at 10 a. m., I saw the patient for the first time. The operation, begun at 10.30 a. m., was not completed until 1.45 p. m., although we worked as rapidly as possible. Under ether, an incision was made through the left rectus muscle; the entire hand of the operator was introduced into the abdomen and the stomach palpated; it was so heavily weighted with the mass of iron that it could not be drawn up into the wound, and I was afraid to prop it up from behind, lest its posterior wall should be perforated, or at least injured, by some of the sharp foreign bodies; so drawing gently on the anterior wall of the stomach, I succeeded in bringing a small portion of it to the surface. The stomach wall was thick and oedematous. An incision into the cavity of the stomach, large enough to admit two fingers, was made, after the abdominal contents had been very carefully walled off with large quantities of gauze. The first thing extracted was a steel chain resembling a small dog-chain; with it came numerous small pieces of glass and some blackish mucus stained with blood and iron and smelling strongly of iron. For fear that, during our manipulations, which evidently would require a long time, we should let fall into the abdominal cavity some of the minute fragments of glass, I sewed a strip of fine linen to the circumference of the wound in the stomach, thus making a funnel, in which to catch even the finest spiculae. It required nearly 2½ hours to evacuate all the bodies which could be felt. Several times I believed that the last piece had been removed, when the peristalsis of the stomach would bring something more within reach. I was much aided by the stomach peristalsis, for our longest forceps could not reach the most dependent point of the stomach. Finally I decided to sew up the stomach, because it seemed impossible to reach anything more from this opening, which was about 6 cm. from the greater curvature, and perhaps 10 or 12 cm. from the pylorus. I did not introduce my hand into the abdominal cavity to explore bimanually for

additional foreign bodies, fearing to infect the peritonaeal cavity; so after sewing up the stomach wound completely, we all disinfected our hands thoroughly and made a fresh toilet of the abdominal cavity; then on palpating the stomach which could now be drawn easily into the wound since almost all of the foreign bodies had been removed, it was evident that a knife-blade and several smaller foreign bodies were still present in the stomach. A second incision was then made in the stomach much nearer the cardiac orifice than the first, and just over the pouch in which the remaining foreign bodies were lodged, and from this second incision, which was only large enough to admit one finger, these bodies were removed in a few minutes. This stomach wound was then tightly closed, as was the first, with a double row of mattress sutures. The mucous membrane of the stomach seemed to be considerably injured by the foreign bodies, and great care was exercised in the extraction of these bodies lest further laceration of the stomach wall should occur. Many of the bodies during the operation were removed with large scoops, but most of them with forceps. Blood came away with each scoopful of glass and tacks, and it seemed to me that perhaps more damage resulted from the employment of the scoop than of the forceps. On examining the walls of the stomach after the operation was over, two minute, subperitonaeal extravasations, pin-head in size, were discovered on the posterior surface of the fundus of the stomach. The abdominal wound was closed with silver wire; mattress sutures for muscle and fascia, and a continuous buried suture for the skin. The patient was infused with salt solution immediately after the operation.

March 16th.—Pulse ranged from 100 to 160; temperature from 100.5 to 104.9. Intense thirst; mind perfectly clear; great tenderness on palpation. Abdomen not distended. Patient is flushed and slightly cyanotic.

March 18th.—Patient is still flushed, with a distinct suggestion of cyanosis; but neither pulse nor temperature evidence infection.

March 20th.—General condition good. Abdomen not distended. Patient still flushed. Yesterday patient passed a large quantity of coffee-ground material. He appears to be perfectly comfortable.

March 21st.—Patient has some cough and complains of pain in wound on coughing. Binder removed and dressings replaced. Wound reported as dry and looking well. Abdomen not sensitive to pressure.

March 22d.—Patient obtained, surreptitiously, some bread, coffee and water from other patients. Comfortable all day, but about 9 p. m. began to complain of abdominal pain. Wound reported healed per primam. Abdomen slightly distended.

March 23d.—Patient's cough continues. He complains of pain in the wound on coughing. Condition good. Patient has no abdominal symptoms. The wound, which had apparently healed per primam, has broken down throughout its whole length and depth. The recti muscles, so far as exposed during the operation, are covered with a necrotic film. In places there is considerable sloughing of the tissues. Patient's cyanotic flush has disappeared.

March 24th.—About 12.30 patient began to complain of pain in the wound. On investigation the wound was found to be widely open; out of its lower angle there protruded a knuckle of bowel. The bowel was immedi-

ately replaced and retained by gauze packing. Patient's general condition excellent. No elevation of temperature and no signs of general peritonitis.

April 4th.—Patient is receiving soft diet—eggs, milk, toast, etc. All packing has been removed from the wound. In the lower angle of the wound is still to be seen a small knuckle of gut covered with granulations and adherent to the parietal peritonaeum.

April 15th.—Patient is well. He has a good appetite and is permitted to eat what he fancies. The wound is reduced to a narrow granulating sore. His abdomen is no longer sensitive to pressure. No foreign bodies have been passed per anum since the operation.

Articles swallowed:

	20 pieces of small dog-chain	460 cm.
	1 piece of large dog-chain	29 "
	4 watch chains	31 "
	1 brass chain	59 "
	2 pieces of chain	15 "
28		594 cm.
	10 horseshoe nails.	
	54 wire nails (16 of these 7½ cm. long).	
	35 ordinary nails (8 of these 6 cm. long).	
99		
	8 screws (2½-3 cm.).	
	2 screw eyes.	
	7 knife blades.	
	1 knife handle.	
	50 tacks.	
	12 pins.	
	1 piece of tin.	
81		

208 articles and 74 grms. of broken glass. See Plates VI, VII, and VIII.

In a recent article by Hecht in the Wien. med. Woch.,[2] we read: "As I find from consulting the literature, gastrotomy, even in the preantiseptic and preaseptic times, was an operation comparatively free from danger." I have found only four authentic cases of gastrotomy for foreign bodies in preantiseptic times in which the stomach was not, at the time of the operation, adherent to the parietal peritonaeum. One of these cases died on the third day after the operation; in two the wound of the stomach was very small and not even stitched, and in the fourth case "the threatened peritonaeal symptoms were conquered by collodionated cuirass, compression and champagne frappé." One could not, fortified only with the knowledge of

[2] Wien. med. Woch., 1898, Bd. xi, No. 46, S. 1045.

these cases, proceed, with great confidence to do a gastrotomy for the removal of foreign bodies.

In 1880 Poulet[3] wrote: "The operation of gastrotomy is hardly accepted by all surgeons, and the small number of cases which the literature contains testify to the scant sympathy it has met with for centuries, and to the rarity of its indications. Gastrotomy is, nevertheless, a very old measure, since it is found in the writings of authors who lived before the reign of Louis XIV. One of these cases quoted by Hévin bears the date of 1636; that of Crollius occurred in 1602; but since that period, despite the thousands of cases of foreign bodies which have been accumulated, there are not more than 20 cases of gastrotomy."

Credé[4] in 1886 collected 26 cases, but in nine of these the stomach was at the time of operation adherent to the abdominal wall, and in seven it is not stated in the unsatisfactory reports of the operators whether the stomach was adherent to the wall of the abdomen or not; in two of the seven badly reported cases, even the result is not given. Until 1886, therefore, we find collected only ten cases in which the stomach was not adherent to the parietal peritonaeum when it was opened for the removal of a foreign body. Two of the ten died. Only one foreign body was removed from each stomach in the remaining eight cases; in all, 1 table knife, 1 leaden bar, 1 fork, 1 broken coin-catcher, 2 hair balls, and 2 sets of false teeth. Foreign bodies are swallowed most often by the insane and by jugglers, yet among the eight cases prior to 1886 which recovered from gastrotomy, there was, I observe, not an insane person nor a juggler; but of the two gastrotomized patients who died from the operation, one was insane and the other a professional sword-swallower.

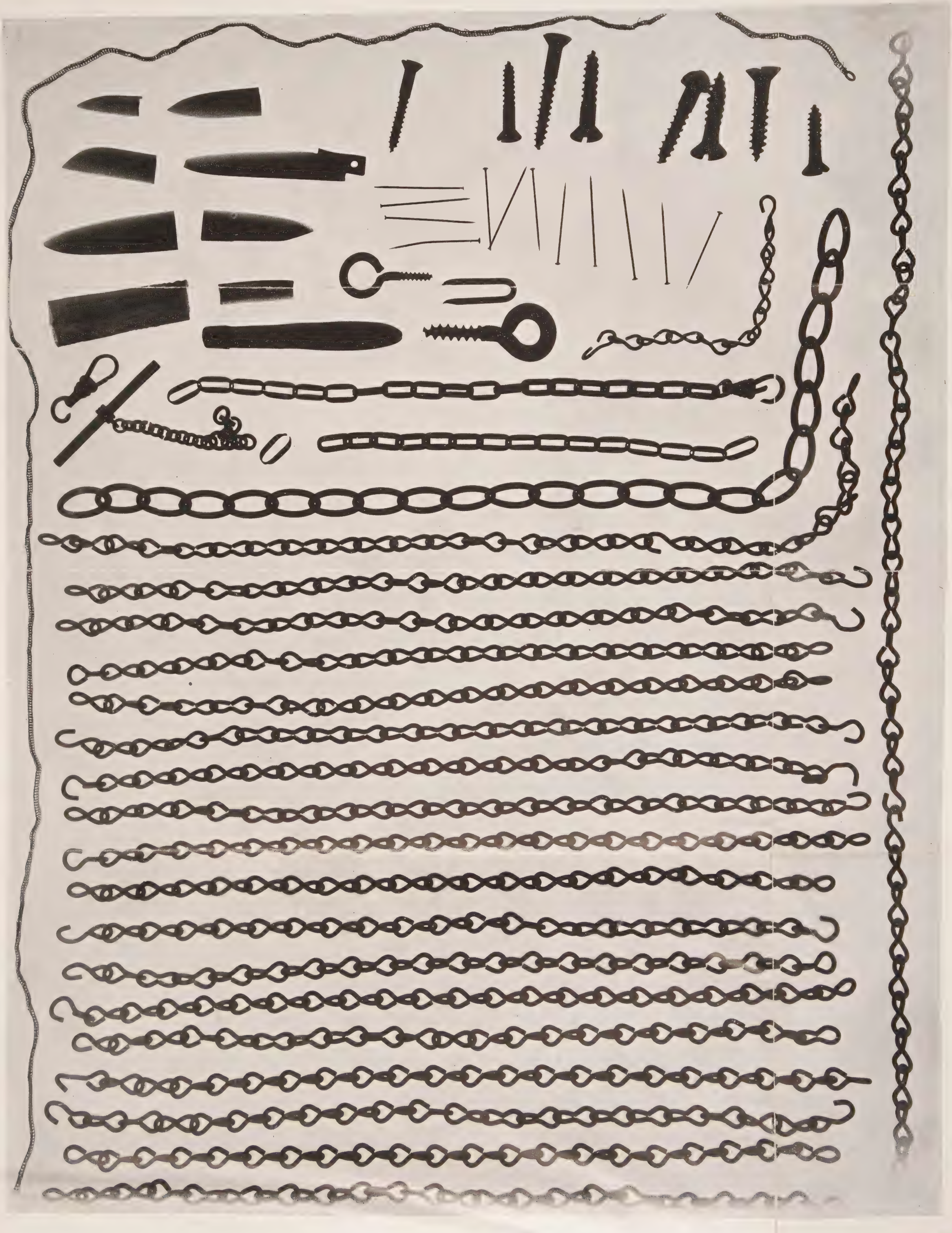
The insane patient,[5] a woman, aged 32 years, had swallowed a silver spoon 21 cm. long; the juggler,[6] a youth aged 19 years, a piece of sword blade 27 cm. long and 2 cm. broad. Both of these cases were evidently in very bad condition when operated upon.

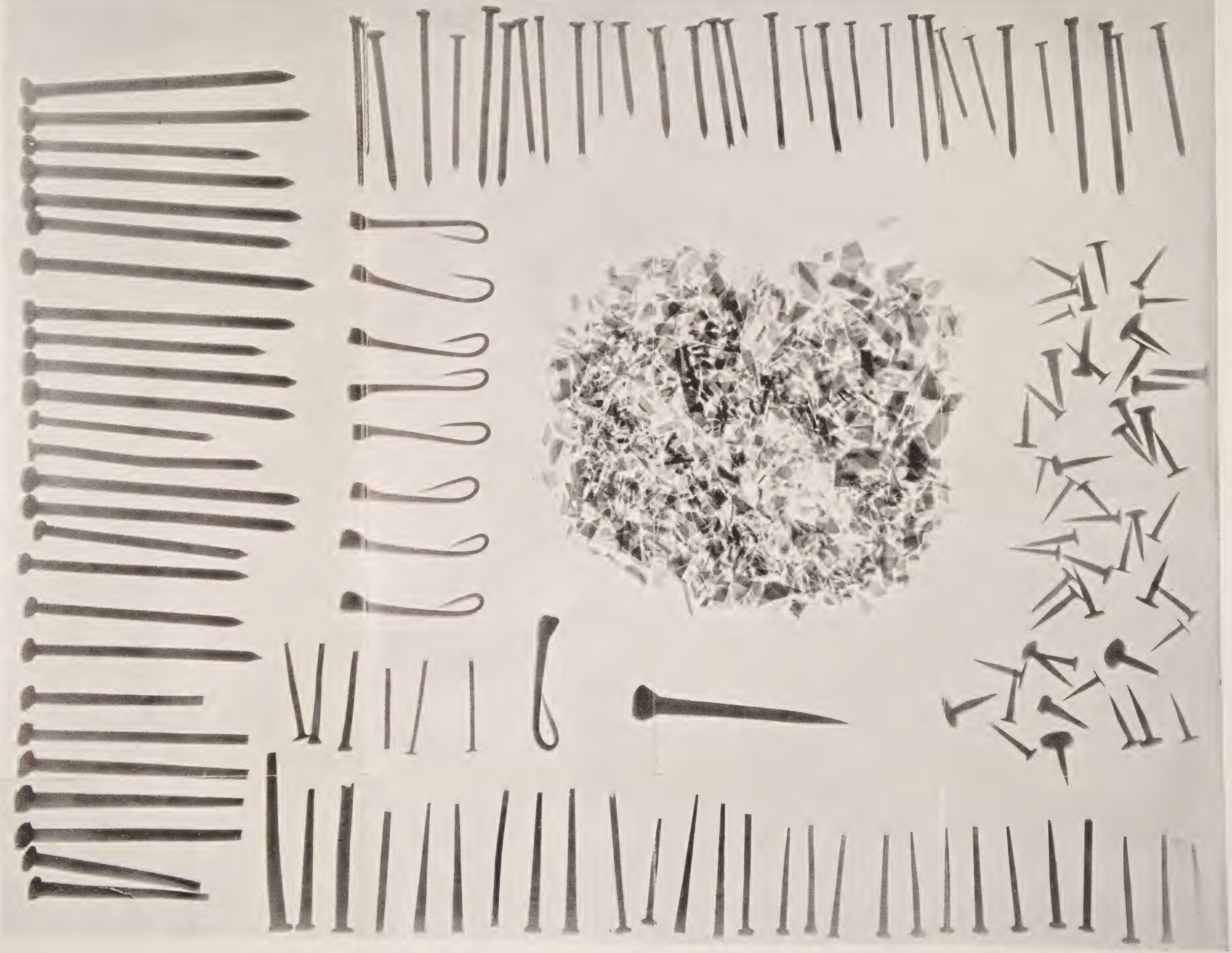
Insane people swallow foreign bodies usually with suicidal intent; and only when their suffering is more than they can bear do they confess what they have done. Even then they are often disbelieved, and so the operation is postponed and the chances for recovery lessened. Jugglers, too, have contributed more than their proportion to the mortality roll. This is partly due to the fact that the very large objects (*i. e.*, pieces of sword blade) and objects in large quantities have been ingested principally by men of this

[3] Poulet, Foreign Bodies in Surgery, Wm. Wood & Co., N. Y., 1880.
[4] Credé, Arch. f. klin. Chirurgie, Bd. xxxiii, Heft 3, S. 574.
[5] Case of Tilanus in Leyden, 1848.
[6] Case of Gussenbauer in Prag, 1883.

Skiagraph of the Abdomen before Operation. The Outlines of the Stomach and Pylorus are Distinct.

PLATE VII





class. They, too, are disposed to conceal their suffering, and continue their performances, giving five or six daily, when they know that their distress is caused by the bodies which they have swallowed.

As I have said, Credé in 1886 furnished us with a very carefully prepared table of the cases to date; and the same year, in Maurice Richardson's most admirable contribution,[7] we find several additional cases collected. Then Fricker,[8] in 1887, tabulates 27 cases operated upon since Credé's publication, and contributing a very remarkable case of his own, brings the total number of gastrotomies for foreign bodies in the stomach and oesophagus up to 54. Fricker's table is a full one, giving the principal facts in each case. A year later, Meisenbach,[9] on the lines laid down by Fricker, gives all the cases to date; adding five cases, including a creditable one of his own, he makes a total of 59. In November, 1898, Hecht[10] contributes a case of his own and two others, and appends the bibliography of the subject. In the 62 cases there were only 11 deaths, 17.7 per cent. Hecht attributes to peritonitis only two of these. It is my opinion that peritonitis was at least present in four of the fatal cases, and would surely have supervened in one of the two cases which died of shock, and probably in the other.

In most instances only one foreign body has been present, but in six cases many articles were extracted from the stomach. Three of the six cases died, two of shock within four hours, and one within forty-eight hours. Eleven pounds and nine ounces was the total weight of the articles removed from one of the fatal cases. Of the three that lived, Mayo Robson's[11] furnished the greatest number of foreign bodies, viz., 42 cast-iron garden nails $1\frac{5}{8}$ inches long; 93 brass and tin tacks from $\frac{1}{2}$ to 1 inch long; 12 large nails, some brass-headed; 3 collar studs, one safety-pin, and one sewing needle. During the 22 days following the operation there passed, per anum, embedded in hard faecal matter, thirty garden nails, a piece of needle, one stud, eight tacks and a pen. This patient of Mr. Robson's was only ten years old, said to be an intelligent girl who apparently could not control her morbid appetite, for after her recovery she continued to swallow articles which she could not digest.

The second case was also a remarkable one. A woman, during a temporary attack of insanity, swallowed the articles which Fricker[12] subsequently removed: 1 key, 2 teaspoons, 1 fork, 2 pieces of wire, 2 hair-pins, 12 pieces

[7] Richardson, Boston Med. & Surg. Jour., 1886, vol. ii, p. 569.
[8] Fricker, Deutsche med. Wochenschr., January, 1897, S. 56.
[9] Meisenbach, Journal Am. Med. Assoc., March, 1898, p. 513.
[10] Hecht, Wiener klin. Wochenschr., November, 1898, S. 1045.
[11] Mayo Robson, Lancet, 1894, p. 1028.
[12] Fricker, Deutsch. med. Woch., January 21, 1897.

of glass, 1 window-latch, 1 steel pen, 9 sewing needles, 1 piece of graphite, 1 shoe button, 1 crochet needle, and *one grape seed.* Quite a large abscess had formed, and through it the crochet needle was withdrawn; but the other bodies were removed through an incision which Fricker carried through the posterior wall of the abscess into the stomach and also into the general peritonaeal cavity; fortunately general peritonitis did not result.

Meisenbach's [13] is the third successful case of the kind. He extracted 25 staples for barbed fence wire; 15 one and one-half inch screws; 6 two-inch horseshoe nails; 16 two-inch wire nails; 30 one and one-half inch wire nails; 16 thirty-two calibre cartridges; 5 thirty-eight calibre cartridges; 2 pocket-knife blades (broken); 2 inches of brass washstand chain, and 2 small staples; total 119 pieces. Eight cartridges passed after operation. There was also one ounce of comminuted glass (electric light globe), making the total number of objects 127, total weight, one pound.

That peritonitis was avoided in my case, notwithstanding the facts that the stomach could not for a long time be drawn out of the abdominal cavity, and that the operation lasted so many hours, is probably in part due to: 1. The small openings into the stomach which could be quite perfectly controlled. 2. The employment of the strip of linen which was sewed just outside of the edges of the incision into the stomach wall to prevent the escape into the abdomen of small particles of glass. This is not a theoretical danger; for quite large bodies have been found free in the abdominal cavity which could only have escaped through the gastrotomy wound. 3. The great care exercised and the large amount of gauze used to prevent soiling of the abdominal contents. 4. Postponing a second bimanual examination of the stomach until the first incision into the stomach had been sutured, until a fresh toilet of the abdomen had been made, and until the hands of the operator and assistants had been disinfected. 5. The very thorough suture of the stomach wounds.

Suture of the stomach.—The stomach wound should be most carefully sutured, and unless some contraindication exists the stomach should be dropped back into its normal position. With a running stitch through the mucosa, close off the stomach cavity so that the parts no longer soiled by stomach contents may be carefully cleansed before the next row of sutures is taken. Catgut may be used for this suture of the mucosa; next a row of mattress sutures of fine silk; each stitch of this row should enter the submucosa but not the mucosa. A third row of stitches is important as a safeguard against a possible perforation of the mucosa by one of the stitches of the second row. I have, within a year, produced a fatal peritonitis by a

[13] Meisenbach, *loc. cit.*

single stitch which entered the lumen of the stomach. The stitches of the third row should include only the muscular coats of the intestine. It is, as I have frequently pointed out, incorrect to speak of a suture of the peritonaeal coat, for even if the peritonaeum were not destroyed by the manipulation, it is too thin to play any part whatever in the suture of the intestinal wall; and twice, recently, I have observed that the wall of the intestine, although deprived of its peritonaeum, can dispose of microorganisms virulent enough to produce an acute toxaemia and extensive superficial necrosis of the muscles and fat of the abdominal wound. In the case which we are considering, it is possible that the gastric juice lowered the resistance of the tissues which succumbed so rapidly to the infection of the abdominal wound.

SURGICAL TREATMENT OF TUBERCULOSIS

CASES OF PARTIAL RESECTION OF THE ELBOW AND SHOULDER FOR TUBERCULOSIS, AND OF THE ANKLE FOR TRAUMATISM[1]

CASE I.—*Elbow.*—A man, aged thirty-six, believed that a brother had died of consumption. His family history was otherwise good. About two years ago pain, spontaneous and insidious, developed in the right elbow, but until July, 1884, the patient's suffering had been inconsiderable. His sleep was little disturbed, and moderate movements of the affected joint did not cause pain. On his admission, July 22, 1884, there was consolidation at the apices of both lungs. The specific gravity of the urine was 1028, and it contained oxalate of lime. There was a spindle-shaped enlargement of the right elbow joint, with fluctuating swellings to the outer side of and behind both condyles of the humerus. Flexion, possible only to less than a right angle, was painful. The inner swelling was incised and about one ounce of cheesy pus was removed. September 3d, the patient's elbow having for several weeks annoyed him greatly, injections of iodoform ointment were made through a fistulous tract into the joint, and contributed at first to his comfort. Anodynes, even in large doses, gave little relief. There was much redness about the joint, and the slightest motion caused great pain.

Ether having been given, Esmarch's bandage was applied, and as strict antiseptic precautions as practicable were observed. A longitudinal incision was made, eight inches in length, parallel to and just to the inner side of the inner border of the olecranon. Then a transverse incision was made, at right angles to the first one, outward to the plane of the radius, opening the joint and dividing the triceps muscle close to its insertion into the upper border of the olecranon process. A short longitudinal incision was then made at right angles to the second incision, and parallel to the outer border of the olecranon, to the neck of the radius. Dr. Halsted preferred dividing the triceps to sawing through the olecranon, as proposed and practised by Bruns, and practised by Mosetig Moorhof and others, and by Dr. Stimson in the case just presented by him, because it was simpler in the first act, viz., opening the joint, and in the subsequent acts, should it prove necessary, as it almost invariably must, to remove the articular surface of the olecranon. The joint then being still more thoroughly exposed by liberating the sides of the olecranon from the triceps and anconeus attachments, all the articular surfaces were found to be more or less involved in the disease, which was distinctly tuberculous with, fortunately, sclerotic confines. The articular surfaces of the humerus, of the head of the radius, and of both sigmoid cavities were sawn off, also the upper surface of the olecranon. Thus a

[1] Presented at the New York Surgical Society, November 11, 1884.
N. York M. J., 1884, xl, 619-620.
Also: Med. News, Phila., 1884, xlv, 662-663.

rectangular replaced the sigmoid cavity somewhat as figured in Leinhart's "Operationslehre." The capsule and articular ligament were completely dissected out and the walls of the sinus scraped with a Volkmann's spoon. The end of the humerus was sewed with catgut into the step made in the olecranon, and the space necessarily left between the humerus and the radius was obliterated by turning into it the divided triceps and anconeus muscles, which were retained by several "Einstülpungsnähte." Other small dead spaces were obliterated by quilted sutures. Wound was closed by the furrier's suture, and three short drainage tubes were introduced. The dressing was applied previous to the removal of Esmarch's elastic bandage, and the limb, flexed to about 45°, was preserved from constriction by the introduction, in the dressing, of narrow strips of wood to distribute the pressure made by the tightly applied bandage. The arm was, of course, maintained elevated for about thirty-six hours.

September 6th.—The dressing was changed; the edges were perfectly united; there were no signs of inflammation.

September 15th.—Redressed. No pus. Rectangular splint applied.

September 26th.—A small subcutaneous abscess in the cubitus opened, apparently having no connection with the joint.

The patient, as presented, seemed to have a perfectly healed joint. There still remained in the cubitus the mouth of a subcutaneous fistula, about half an inch in length, which did not, apparently, lead toward bone. Although it was but six weeks since the operation, the patient could flex and extend the elbow moderately and without pain. Dr. Halsted advocated partial as opposed to so-called typical resections of the elbow joint for tuberculosis.

Case II.—*Shoulder.*—I. H., male, aged fifteen years. No tuberculosis heredity ascertained. All the members of his immediate family alive and healthy. About the middle of April, 1884, he wrenched his left arm while lifting down a coal-scuttle. He felt pain immediately in the left shoulder joint, severe enough to prevent sleep for three nights. On the fourth day the pain had subsided, except on motion. A few days later he applied at the Roosevelt Hospital Out-Patient Department for relief. The muscles about the joint were then much atrophied. The head of the humerus on the affected side appeared smaller than on the sound side. The joint was not thickened at any part, but was fixed by muscular action. Passive motion and palpation of joint were painful. There were no points of special tenderness. A plaster of Paris splint was applied, and on August 20th, when the splint was removed, there had been no pain whatever since its application. There was a fluctuating tumor of about the size of a pigeon's egg at the back of the joint, under the deltoid muscle. The skin over it was normal. August 26th, about one drachm of flocculent pus was withdrawn from the abscess with a Pravaz's syringe, and iodoform ointment (iodoform, one part; almond oil, two parts) was injected into the abscess cavity. Examination of the pus by Dr. R. J. Hall revealed, from eight cover-glasses, five tubercle bacilli.

August 27th.—Patient was confident that he had been benefited by the iodoform injection, and unwillingly allowed a repetition of the aspiration and injection of the cavity, which had more than attained its former size.

September 14th.—Condition essentially unaltered.

September 16th.—Arthrotomy was performed by a posterior incision through the abscess, leading directly into the joint, which was distended with pus. The much-diseased head of the humerus was sawn off at the surgical neck; the glenoid cavity and capsule, also extensively involved in the tuberculous process, were scraped with a sharp spoon. The furrier's suture was used, and a short rubber drain was inserted at the lower angle of the wound.

September 30th (two weeks after the operation).—Original dressing removed. Wound healed, without pus, to the drainage tube. Tube removed.

October 10th.—Second dressing.

November 1st.—Wound entirely healed. Free passive motion does not cause pain; active movements inconsiderable. Electricity applied to the deltoid.

On presenting the patient, whom he had not seen for one week, Dr. Halsted discovered a small fistulous tract at the lower angle of the wound.

The interesting features in the case were its traumatic origin, the immediate atrophy of the deltoid muscle, the failure of iodoform injections, the rapid healing of the wound, and the early partial restoration of function.

Case III.—*Ankle.*—C. L., aged twenty-seven years, was admitted to Roosevelt Hospital October 17, 1883. Just before admission he had been thrown from a horse, and, as he fell on his feet, his right foot turned under him. The tibia and fibula protruded from an extensive wound on the outer side of the ankle, the foot being strongly supinated. Both malleoli were broken off and adherent to the dislocated foot. The patient was etherized, and the malleoli were removed, together with two inches or more of the lower ends of the splintered upper fragments of the tibia and fibula. The furrier's suture was used. A rubber drainage-tube was passed through the joint.

October 30th.—Wound dressed for the first time. Complete union along the lines of suture.

November 7th.—Second dressing; superficial ulcers where the drainage-tube had been.

December 14th.—Patient walks with crutches. On presentation, he walked easily with lateral brace. He could flex and extend the ankle quite as much as, if not more than, on the sound side, notwithstanding the shortened leg bones.

Corrosive-sublimate solution, 1 to 1,000, was used as the irrigation fluid, and iodoformed gauze as the dressing, in the three cases. The wounds healed in all primarily.

A TUBERCULOUS KNEE-JOINT[1]

Our first case is that of a tuberculous knee-joint which we exsected. The patient is a woman of 40 years of age, and her trouble commenced a year and a half ago. When she was admitted to the hospital she was suffering greatly and wished to have the knee operated upon. The disease was quite advanced, the entire capsule being involved. There were no foci of disease in the bone, so that we could in this instance do an operation which we do in all cases of ankylosis from any other cause than tuberculosis. Instead of excising a wedge-shaped piece as is ordinarily done, and shortening the leg a good deal, we simply take off the head of the tibia and make in it a concavity.

In this way we do away with the necessity of sutures; the bones fit accurately into each other, and there is no tendency to lateral displacement. There is a tendency to flex backwards, but it is easy to apply extension in such a away that stitches are practically superfluous. The operation was done nineteen days ago. Of course it is too early for ankylosis, but it is quite firm already. This is the first time we have looked at the wound since the operation. The result is very good.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, April 3, 1893.

Johns Hopkins Hosp. Bull., Balt., 1893, iv, 97.

EXCISION OF ONE-HALF (ANTERIOR) OF THE HEAD, NECK AND UPPER PORTION OF THE TROCHANTER OF THE RIGHT FEMUR BY FRONTAL SECTION FOR TUBERCULOSIS OF THE HIP-JOINT[1]

To indicate what we may hope for as a final result in certain cases of hip-joint disease, even when a considerable portion of the head of the femur has been removed, and in support of what Dr. Bloodgood has said, I will refer very briefly to a case which I intend very soon to report in full with other interesting hip-joint cases. The patient, a boy, thirteen years old on admission, had an acute osteomyelitis in 1895, at the age of eleven, which involved the entire diaphysis of the right femur. Eleven months he spent in bed, and for seven months could not lie on the affected side. After walking about with a cane and without much pain for more than a month he had to take to his bed again for a week during a second acute attack of pain in the same bone. Two or three months later two abscesses appeared, one behind the knee and one internal to the trochanter. The boy was thenceforth for nearly a year quite comfortable and considered himself sufficiently well, until the first of November, 1897, when he was hit in the right groin by a wagon-pole. He suffered greatly from this blow, and the following morning could not flex his thigh. Two weeks later, November 19, 1897, he was brought to us by his physician, who stated that for several days he had been having very high fever with daily intermissions. The boy was emaciated; his expression anxious and indicative of suffering. He lay on his back; the right thigh was abducted, rotated outwards and slightly flexed; the groove in the right groin was obliterated and there was an appreciable fulness over the head and neck of the femur. Pressure over the joint and all attempts to move the head of the femur caused pain. About the level of the top of the trochanter of the right femur, but internal and anterior to it, was a sinus from which pus escaped. Behind the inner hamstring tendons was the orifice of a second sinus discharging more pus than the other. The femur was much enlarged, and the soft parts of the thigh were swollen. An involucrum had evidently replaced the entire diaphysis. A probe in the

[1] Remarks in discussion of Dr. Joseph C. Bloodgood's paper. "Early exploratory operations in tuberculosis of the hip." The Johns Hopkins Hospital Medical Society, Baltimore, May 8, 1889.

Johns Hopkins Hosp. Bull., Balt., 1900, xi, 19.

popliteal sinus touched rough bone. The measurements, which developed a fact or two of interest, I will give at another time.

First Operation. November 24, 1897.—Excision of one-half (anterior) of the head, neck and upper portion of trochanter of the right femur by frontal section.

There was a small abscess containing only a few drachms of pus just below and in front of the capsule of the hip-joint, which communicated with this joint. The wall of the abscess was carefully excised. Having made the frontal section of the trochanter, neck and head of femur, the extent of the disease in these parts could be accurately determined. The upper end of the soft sequestrum was cut off. The disease had involved the neck and head and had finally, perhaps just after the blow from the pole, infected the hip-joint. By some oversight no drawing was made of the lesions in the head, neck and trochanter. Nowhere were there signs of active bone disease; there was a little sequestrum near the top of the trochanter, and a little, very slender bit of sequestrated bone in the neck; the shape of the head and of the neck was not altered by the disease; the head of the bone had lost some of its cartilage, and granulations were growing from the denuded parts. The infection of the joint was probably recent, and it could be demonstrated how this might have taken place. It was not contemplated at the outset to do more at the first operation than to relieve the trouble about the hip-joint, for the patient's condition contraindicated an extensive operation. The patient recovered promptly from this and from two subsequent operations upon the middle and lower thigh. As you may see in the photographs, the boy can extend his thigh perfectly, and can flex it to nearly a right angle. He walks without a cane and says that he finds the right thigh as useful as the left. The operated thigh is from 1 to 1.5 cm. longer than the other; and there are 2 cm. of apparent lengthening on the right or operated side. This apparent lengthening is due in part to abduction and will undoubtedly disappear.

This case sheds a new light upon the surgery of the hip-joint, proving as it does that not only a useful but functionally an almost perfect joint may be obtained even when one-half of the head and neck of the femur have been removed by, approximately, a frontal section.[2] We may, therefore, attack tuberculous cases in the early stages in some such conservative way, taking a fine and very thin slice from the anterior surface of the neck or head, or trochanter, or from all, and having located the disease, excise only as much as may be necessary. The acetabulum can be explored in a similar manner. If the disease is operated upon early it would probably rarely if ever be necessary to remove the whole head of the femur; and we may find that having removed a part of the disease the remainder, as in tuberculous peritonitis, may take care of itself the better for having been interfered with and assisted.

[2] Original procedure (W. S. H.).

The hip-joint, a simple ball and socket joint, promises more for these conservative operations than any other joint; large surfaces covered with cartilage do not lend themselves so readily to the formation of strong adhesions and ankylosis as the less simple joints; of all the joints the knee is perhaps the least suitable for conservative surgery. With its ligaments and reduplication of synovial membrane, with its fibro-cartilages and numerous recesses and pockets it furnishes conditions well suited to the propagation of the tubercle bacillus; and when the crucial and lateral ligaments have been much weakened by the disease, an ankylosed joint is usually more serviceable and more comfortable than one in which motion has been secured.

RESULTS OF THE OPEN-AIR TREATMENT OF SURGICAL TUBERCULOSIS[1]

Planned and partly written more than ten years ago, this paper was not completed until last autumn (1904), when the private clinical material seemed large enough and to have been observed long enough to make the report convincing. Even now my list of private cases of surgical tuberculosis is not a long one. It is not to be expected that people accustomed to luxury, and, particularly, when in poor health, should relish the prospect of a winter in a boarding-house at Saranac. I am, therefore, under great obligations to the patients who have so courageously and with such implicit trust yielded to my very earnest solicitations to exile themselves for a winter at least. Today we cannot well realize the amount of faith which this required 15 years ago, when not a single precedent could be cited, when one could indicate no case of surgical tuberculosis which had been treated in even a most desultory out-of-door fashion, and when patients, encouraged to believe that they would get well if they remained at home and indoors, asked me to explain how mountain air, inhaled ever so deeply, could reach the bone.

The sanatorium of Dr. Trudeau, at Saranac Lake, had been in existence only about four years when, in 1889, soon after my call to The Johns Hopkins University, I first met him, and one afternoon listened for hours, charmed by the story of his life, his work, and his dreams for the future. He eagerly welcomed the suggestion that possibly all cases of tuberculosis, irrespective of the situation of the lesion, might be benefited by the treatment which he believed was proving to be of great value for pulmonary tuberculosis. The milder the case, or, in other words, the more nearly perfect the patient's immunity, the greater, presumably, was the prospect of cure. Hence, cases of bone and lymph-gland tuberculosis, which, under various names, had for tens of centuries been regarded as more or less curable, and certainly as infinitely less to be dreaded than "consumption," seemed eminently proper ones for the open-air treatment.

There is abundant evidence from France, and especially from England, as to the genuineness of the cures of struma and of rickets by the laying on

[1] Presented at the First Annual Meeting of the National Association for the Study and Prevention of Tuberculosis, Washington, D. C., May 18-19, 1905.

Nat. Ass. Study & Prevent. Tuberculosis, Trans., N. Y., 1906, i, 281-303. (Reprinted.)

Also: Am. Med., Phila., 1905, x, 937-946. (Reprinted.)

of the King's hand. The practice can be traced in England to Edward the Confessor (+1066) and in France to Phillip the First (+1108) *Le Roi te touche, Dieu te querit.* From the official register it appears, for example, that 90,798 persons suffering from the "King's evil," were touched by Charles II (1660-1664 and 1669-1682).[2] John Browne, Chirurgeon in Ordinary to his Majesty, the author of four treatises (1684) on the subject, gives a figure even larger in his Charisma Basilicon, or the Royal Gift of Healing Strumae, or "King's Evil," Swellings by Contact, or Imposition of the Sacred Hands of our Kings of England and France, given them at their Inaugurations.

Shakespeare refers to the custom (Macbeth, Act IV, Scene 3):

DOCTOR.—Ay, sir: there are a crew of wretched souls
That stay his cure; their malady convinces
The great assay of art; but, at his touch,
Such sanctity hath heaven given his hand,
They presently amend.

* * * *

MACDUFF.—What's the disease he means?
MALCOLM.—'Tis called the evil;
A most miraculous work in this good King;
Which often, since my here-remain in England,
I have seen him do. How he solicits heaven,
Himself best knows; but strangely-visited people,
All swoln and ulcerous pitiful to the eye,
The mere despair of surgery, he cures;
Hanging a golden stamp about their necks,
Put on with holy prayers; and 'tis spoken,
To the succeeding royalty he leaves
The healing benediction.

The cost of these golden stamps in certain years was more than 3000 pounds, sterling; so great that in Elizabeth's reign silver coins were substituted for the gold. Many of the best known English surgeons, Gaddesden, Gale, Clowes, Bannister, from the thirteenth to the seventeenth century, testify to the marvelous results of this practice.[3] Is it not very likely that the exposure to all weathers, day and night, the life in the open, led by the afflicted on their long pilgrimages to Norway, France, England, effected the cures of the King's evil and deserved all the glory enjoyed by the monarchs endowed with the miraculous touch?

Though the knowledge of opsonins was a little indefinite in the early Adirondack days, it was evident that, in a general way, improvement in

[2] Gurlt: Geschichte der Chirurgie.
[3] Gurlt, l. c.

nutrition, whatever that signifies, is responsible for the subsidence of the disease. After my talk with Dr. Trudeau, a year passed before the patient destined to be the first to make the true experiment in the treatment of surgical tuberculosis presented himself. But in the meantime we were accumulating evidence of a less conclusive kind on the "bridge" of The Johns Hopkins Hospital. The open-air treatment of surgical tuberculosis possibly began with the admission of the first tuberculous patient to the surgical wards of this hospital. He was wheeled in his bed to a spot on the roof of the long corridor. A rough trundle-bed had been constructed for the purpose of transporting beds easily from the wards to the bridge and to the clinics.[4] Although at first the surgical beds on the bridge afforded amusement for most except those whose duty it was to trundle them, very soon the benefit to the patients was so definite and evident that even certain nontuberculous patients, particularly those convalescing from other infections, were also treated to fresh air. Just the other day, for example, a child about 11, operated upon for appendicitis, had a septic postoperative temperature, ranging from 101° F. to 106° F., for nearly three months. Whether general infection or an undiscoverable local focus of infection was responsible for her temperature has never been determined. Her haemoglobin sank to 25 per cent. Finally, when her life was almost despaired of, she was transported to the bridge and, seemingly from that moment, her convalescence and prompt recovery began.

It is a real joy to patients, this life in bed on the bridge. It relieves the monotony of the confinement, and they discover that it gives appetite and sleep and vigor. After a severe surgical operation, patients, if restless and sleepless, often find that the day out-of-doors in bed refreshes and soothes them and insures a peaceful night and a morning minus the headache incident to an anodyne. And what a boon it must be to the typhoid convalescents, to those suffering from the so-called posttyphoid septicaemia. The main rectangular corridor is 12 feet wide and more than 1300 feet long; hence, the length of the veranda or "bridge," its roof, is about a quarter of a mile. I have intended for years to ask the distinguished designer of the hospital, Dr. J. S. Billings, if he had in mind any such possible use for the bridge when he planned it. This treatment of patients with surgical tuberculosis has been carried on uninterruptedly for the past 16 years; and now, every day, with few exceptions, winter and summer, the bridge is strewed with the sick.

[4] The idea and the design for this trundle we brought from the great clinic of Volkmann, in Halle, where it was used to transport beds from the wards to the amphitheatre, and from ward to ward.

But it is from my private patients that I have learned the almost incredible value of the true out-of-door living in the treatment of surgical tuberculosis.

I have treated no patient, the hospital cases excepted, who would not or could not live out of doors in the manner prescribed.

There follows a brief abstract of all the private cases, and, hereupon, the fuller histories of the first four of these, which latter were the pioneer patients, the experimental cases, and have been under observation for many years. They were also serious cases whose progress has been watched with unusual concern and satisfaction:

Case I.—Pott's disease with sinuses. Enormous waxy liver. In bed, very ill, and supposed to be dying when he consulted me in 1890. Transported in private car to Saranac Lake. Restored to fair health, married, father of three children, lived 12 years, died of nephritis. (Fuller history follows.)

Case II.—Child, aged 15. Family history of tuberculosis. Hip disease a year and a half. Large abscess in or about joint February, 1893. Iodoform injections; rigorous out-of-door treatment at home in Maryland and mountains of Pennsylvania for seven years; then January, 1900, to Adirondacks, where, in five weeks, she gained nine pounds. On her return she looked really well, for the first time since my first examination. Brace and crutches were discarded, and riding, driving, walking, dancing, and social pleasures were freely indulged in with true relish after the long, weary years of life in a chair on the piazza. But day after day, and night after night, our patient's strength was taxed (1900 and 1901) and the hours on the piazza became fewer and fewer, and finally none. Then, in less than two years from the time "cured" (December, 1901), she noticed a little swelling and stiffness above the right wrist, for which she soon consulted me. Her general condition was poor, almost bad.

Diagnosis.—Tuberculosis of tendon sheaths. At operation a very active and extensive process from palm to upper third of forearm was revealed; thousands of fresh tubercles in sheaths and muscles were carefully removed. Patient went eagerly and promptly after the operation to Saranac, where, in the first month, she gained 16 pounds. The winter was spent in the Adirondacks and the summer in the Austrian Tyrol. May, 1903. Patient enjoys perfect health. She walks with a hardly noticeable limp. Flexion permitted to a right angle at affected hip, although the head of the femur has disappeared. The slightly expanded end of neck occupies the acetabulum. The function of hand and wrist is perfectly restored. Results like this, very rare in the past, will be common in the future. (Fuller history follows.)

Case III.—Mrs. ——d, aged 28, March, 1894. Sister died of pulmonary tuberculosis, aged 36. Is very delicate and neurotic. Fluid in right knee-joint. Typical tender points. Iodoform injections, at my suggestion, by the late Professor Dabney, of Charlottesville, Va. Life out-of-doors in Virginia conscientiously carried out. June, 1894, no improvement. Adirondacks

urged, but not feasible. Injections continued by Dr. Dabney. October, 1895, disease progressing rapidly. Resection considered. November 5, 1895, patient presented herself in Baltimore for operation. She coughed and had fever. Examination of lungs revealed apical involvement. Consented to go to the Adirondacks. Pulmonary haemorrhage en route. Weight, 86 pounds. Normal weight, 104; greatest weight, 112 pounds. Arrival at Saranac, examined promptly by Dr. Trudeau. His prognosis guarded, but rather unfavorable. On subsequent examinations it proved that the disease, though incipient, was still advancing; prognosis more decidedly unfavorable. For several months no improvement, then a slight gain, and in August, 1896, she weighed 95 pounds, a gain of nine pounds in about nine months. Circumstances made Adirondacks too difficult. The mountains of western North Carolina were suggested, but patient was so much encouraged that she returned to Virginia. There she slowly but surely lost ground. Eventually, October, 1897, she made her home in the North Carolina mountains. The lesson learned at Saranac was of great value here. She lived the true, open-air life faithfully.

In September, 1898, I found astonishingly great improvement in the condition of lungs and knee, and in a few months discontinued the plaster cast. In May, 1899, weight 97 pounds. In January and February, 1900, she visited in Virginia and lost much ground. Possibly developed a slight pleurisy. Returned to North Carolina and gradually regained what was so rapidly lost. November, 1900, knee still better. January, 1901, motion in knee returning. Then a second visit to her home in Virginia again; and promptly, a pleurisy; she became so ill that it was difficult to return to North Carolina. January, 1903, examination. I could hardly believe what I saw. The right knee-joint looked perfectly normal, except for a very slight fulness on either side of the ligamentum patellae.

Under Dr. Thayer's care this patient has gained more than 20 pounds within a few months. He is unable to find a trace of the pulmonary disease which at one time was so active as seriously to menace her life. (Fuller history follows.)

Case IV.—Miss ——l, aged 38. Tuberculous family (sister, uncle and aunt). Hip-joint disease; initial stage. Tuberculin reaction. Modified open-air treatment in Pennsylvania for eight months. Through misunderstanding, considerable exercise was taken. Disease made such definite progress that I became alarmed and urgently advised Adirondacks. Immediate and great improvement in general and local condition at Saranac Lake. Brace and crutches discarded three years after first examination. Motion at hip-joint almost perfect. Unless very careful comparisons with the other hip are made there is no indication of impairment of function. Even the apparent shortening (adduction) which the brace could not overcome and which persisted for nearly three years, has vanished. Only the reaction to tuberculin remains. (Fuller history follows.)

Case V.—Miss ——m, aged 14. In September, 1900, fell, striking right hip. Bruise over right trochanter. Attended school regularly. Consulted me about four months later for limp and occasional pain in right knee. Patient seemed in good health, but had lost a little in weight and perspired

easily. There was about 1.5 cm. apparent lengthening of the right leg, but no difference in circumference of thighs and legs on the two sides. Hardly demonstrable limitation of motion in any direction; little if any rigidity of the adductors of the thigh. Extreme hip movements caused pain in the knee of the affected side. Tuberculin was administered three times at her home. The reaction was very slight but definite, becoming more pronounced as the dose was increased. Definite pain in the hip itself was experienced for the first time a day or two after the exhibition of the third dose of tuberculin.

February 13, 1901, admitted to The Johns Hopkins Hospital. Supplied with brace and treated on the "bridge" until May 13, 1901. While in the hospital she was entirely free from pain except for occasional brief twinges in hip and knee.

From the hospital, patient went to Atlantic City for a few weeks and thence to the Adirondacks for the remainder of the summer. During the following winter it seemed so difficult to arrange for patient's departure to the Adirondacks that she was permitted to live in town, spending her days, however, out-of-doors on a balcony. In the spring she had lost so much in weight and her general condition was so unsatisfactory that I almost insisted upon a change. Tuberculin again administered was followed by a prompt reaction, the temperature reaching 103° F. A winter in the Adirondacks completely restored our patient to health.

May, 1905, two years after the institution of treatment a cane was substituted for the brace. In a few months the cane was discarded and patient has led the active life of a young society girl ever since. She has no pain nor limp and seems perfectly well.

Case VI.—Mrs. J——n, aged 34. Admitted October 4, 1902. Diagnosis, sacroiliac tuberculosis. Two years ago pleurisy in left side. No night sweats and no shortness of breath.

Present illness began in April, 1902. Patient felt slight twinge in back on getting into carriage. Next day had severe pain in region of sacroiliac synchondrosis. Since then patient has suffered constantly.

Examination.—Considerably emaciated. Gums pale. No tenderness on pressure over spines of vertebrae. Over right half of sacrum is a slight fulness and over this some tenderness. Tenderness also in sciatic notch and along sciatic nerve. Little if any tenderness over Poupart's ligament on right side, except on very deep pressure. In August, 1902, in Virginia, patient's ovaries and appendix were removed.

October 16th, Operation, Cocaine, Dr. Halsted.—Aspiration of tuberculous abscess over sacroiliac articulation. Iodoform emulsion injected.

November 1st, Operation, Ether, Dr. Halsted.—Exploration of right sacroiliac joint. Excision of the walls of a tuberculous abscess and of a portion of the sacrum. A large abscess was discovered in the pelvis, communicating with the one above. The walls of the pelvic abscess were cleaned as well as possible, but some portions were inaccessible from this opening.

February 3d.—Since operation, patient has been kept out-of-doors in bed, but her weight, which is normally 135 pounds, is now only 98. She has been most carefully instructed as to the life out-of-doors, and has promised to follow directions implicitly. Discharged.

April 8, 1904.—Patient returns for examination. She is in perfect health and weighs 150 pounds. Since leaving the hospital, two years ago, she has lived out-of-doors faithfully in all weathers; has slept indoors, but with windows wide open. The sinus leading to the pelvis is closed. There is no sign of disease in the pelvis or at the site of the incision in the back. She complains of nothing except that on standing she has slight pains along the course of the sciatic and external popliteal nerves. Extreme flexion of thigh sometimes produces this pain. Patient is not annoyed by it.

Case VII.—Miss B——e, aged 16. Admitted to The Johns Hopkins Hospital, March 25, 1904. About three months ago patient noticed that her neck on both sides was swollen, and believed the swelling to be due to "cold." The "puffiness" soon subsided, leaving "knots" in its place. These have grown rapidly ever since. There has been no pain nor tenderness and, patient believes, no loss in weight; she confesses to some loss of strength. The voice has become husky. Patient is becoming drowsy, and has tendency to sleep continually. No cough.

Examination.—On both sides of the neck are large masses of discrete glands, varying in size from a pea to a Madeira-nut. Together they would probably equal a cocoanut in volume. Left axilla contains six or seven glands; the right seems free. The left epitrochlear is palpable. No enlargement of glands of groin or popliteal space. No masses to be felt in abdomen. Spleen not palpable. Tonsils markedly enlarged. Circumference of neck at level of hyoid bone, 34 cm. On the back of the right hand is a scar from incision for the removal of a small growth, believed at the time to be a ganglion, but which proved to be a solid mass. There is now an elongated, semifluctuant swelling apparently connected with the tendon sheaths. A small gland removed for diagnosis proved to be tuberculous. It was proposed to patient and her friends that the out-of-door treatment be tried and, in case it failed, operation be undertaken. The patient being indisposed to undergo the rigorous out-of-door life, Dr. Follis, the house surgeon, excised, with cocaine, the tuberculous glands of the left neck and left axilla.

April 10th.—Patient discharged, having promised to live systematically out-of-doors. Wound healed per primam.

Readmitted May 12, 1904. Since discharge patient has lived out-of-doors, day and night, without interruption. Though she has had only one month of this treatment, the glands on the right side of the neck have almost entirely disappeared. Only one can be felt, and that exceedingly small. On the back of the left hand, however, at the site of the old scar and running along the tendon sheaths, there is evidence of a tuberculous process.

May 13th.—Excision of tuberculous tissue about the extensor tendons over the left wrist and dorsum of hand, by Dr. Follis. The disease was found to be quite extensive.

June 6th.—Patient discharged. Condition excellent. No enlargement of glands of neck. On the operated side, however, is a keloidal, disfiguring scar.

Case VIII.—M——s, aged 25. Admitted April 11, 1904. Tuberculosis of right knee. About three years ago, after prolonged standing, experienced

first pain in the right knee. He was treated for acute rheumatism for six months, the knee-joint being aspirated 25 times. The fluid withdrawn was dark and turbid, but never bloody. On one occasion an injection of carbolic acid solution (1 to 16) was used. Patient's knee gave him little trouble apparently until September, 1903.

Examination.—Joint much enlarged. Patella floating. No redness, heat, nor especial tenderness. Leg can be flexed to about a right angle. April 13, tuberculin administered. Marked local and general reaction. April 25, arthrotomy, under ether, by Dr. Follis. A considerable amount of purulent-looking tuberculous fluid was evacuated and the joint thoroughly irrigated with a solution of mercury bichloride (1 to 10,000). The capsule was found thickened and oedematous, but there was no evidence of bone foci nor destruction of cartilage, nor caseous tissue. On June 4, Dr. Follis persuaded patient to go to Saranac Lake in the Adirondacks, and arranged for his admission to Dr. Trudeau's sanatorium. Discharged today.

April 11, 1904, patient readmitted to hospital. Since his discharge he has been continuously at Saranac Lake. The knee has been fixed in a leather splint. Patient has gained ten pounds since leaving hospital. He has no cough nor night sweats, and appetite is good.

April 14th, 2 mg. of tuberculin administered, followed by severe reaction.

Examination of Knee.—The joint is spindle-shaped, there being considerable atrophy of the thigh muscles. The patella is movable, and there is little or no fluid in the knee-joint. There are no points of especial tenderness on pressure, but attempts to flex the joint beyond perhaps 15 degrees cause great pain. The findings are somewhat disappointing, but patient is not discouraged, and agrees henceforth to live out-of-doors at night, as well as in the day time, at his home in Montgomery, Ala. Discharged March 18th.

October, 1905, patient readmitted to the hospital. Since March he has lived out-of-doors night and day in Montgomery, Ala., and has noticed from the beginning gradual improvement in the condition of the knee-joint. He looks in robust health, has had no pain in knee or elsewhere. Has used crutches and a leather splint.

Examination.—The knee seems perfectly cured. Flexion is permitted without any pain to an extent almost normal. Except for the scar and the barely perceptible fulness in its neighborhood, for which the scar is probably responsible, the joint in appearance is perfectly normal.

October 13th, 2 mg. of tuberculin are followed by sharp reaction, the temperature rising abruptly to 102°.

Case IX.—Miss ——n, aged 17. Consulted me last March. Below the parotid in the common situation on the jugular vein was a mass of matted glands, larger than a big lemon. They had increased in size rapidly during the few weeks prior to this consultation. Not wishing to alarm the young lady unnecessarily, I did not give tuberculin at once but sent her to the seashore with a skilled attendant for out-of-door treatment. In about a month she returned for inspection. The mass had increased in size and become fluctuant in the most prominent part, and the skin over it was inflamed and at one spot slightly thinned. Tuberculin administered was followed by a sharp reaction. About to sail for Europe, I doubted very much

the wisdom of postponing operation, and debated the matter in my mind for several days.

Argument.—If an operation were performed, it would not make the out-of-door treatment unnecessary or even shorten it. If the skin should break, the resulting scar would be much less than the operative one. The rupture of the abscess would not be attended with any bad results, nor would it, that we know, prolong the open-air treatment or create local conditions less likely to respond to this treatment than if the skin were unruptured. If ultimately an operation should be required, it would almost surely be of less magnitude and at a time when the patient was more robust. Moreover, it transpired that our patient had, at the seashore from which she had just returned unimproved, lived only five or six hours daily in the open air. So we decided to give the open air a fairer trial.

She went to the coast of Maine and lived out-of-doors day and night for about four months. A few days ago, on her return to town, I examined her and to my joy found that only one of the enlarged and inflamed glands was palpable and this no larger than a French bean. The redness of the skin had entirely disappeared and I do not believe that any one from the appearances could have designated the side which had been affected. To surgeons whose *daily bread* not long ago was *tuberculous glands of the neck* (Cohnheim) such a resolution foretells a revolution in treatment.

Cases X and XI.—Two cases of tuberculosis of the urinary bladder, adult males. Operated upon by the author at The Johns Hopkins Hospital in 1892 and 1893. In one, the entire mucous membrane of the bladder was thickly studded with tubercles; in the other, the involved area was small and the disease incipient. Both cases have been quite constantly under observation since their discharge, and both are in good health. The one with the severe and extensive lesions was able to lead the out-of-door life quite constantly. He is well. The other, with the comparatively trivial lesions, has trifled with the treatment and is not perfectly well, although very much better than when he was operated upon about 15 years ago. The histories of these cases are not at hand, so I am unable to report them in full and to give exact dates.

The More Complete Histories of the First Four Cases

Case I.—In February, 1890, the writer was summoned to see Mr. ——n, who at the time was so ill that his life was despaired of by his relatives. The patient, aged 28, received a severe fall when at the age of 3, to which was attributed the illness and spinal curvature, which thereafter speedily developed. At the age of 14, incident to a second fall on his back, an abscess developed rapidly and discharged in the right groin. It soon closed, but only to reopen and close again at intervals ever since. In the winter of 1888 and 1889, abscesses appeared and opened spontaneously in the left groin and above the crest of the left ilium. Thereupon the patient's health declined rapidly until March, 1890, when my first visit was paid him.

At this time he had sharp lower-dorsal kyphosis, an enormous liver and three sinuses, one on each side, below Poupart's ligament, and one above the crest of the left ilium. For several weeks the patient, considerably ema-

ciated, had experienced chilly sensations, and occasionally a real chill, with high fever. He was evidently suffering from retention under tension of the products of inflammation, which, I believed, from rather indefinite symptoms, would point over the right ilium. As he was very feeble and exceedingly nervous, as the indications for immediate operation were not perfectly clear, and as his life at home involved considerable excitement, I urged him to go at once to Saranac Lake in the Adirondacks, intending to visit him later and to liberate the pus if the symptoms should persist. It required very little argument to convince this highly intellectual and accomplished man that it was well worth while to make the experiment. He was transported on a bed in a private car from Baltimore to Saranac Lake; this patient was a pioneer, and possibly the very first case of bone tuberculosis deliberately treated by the open-air method. In the Adirondacks, attended by an excellent masseur, he lived in a tent, and almost immediately after arrival, an improvement in his general condition began, although there were periods when the daily fever would be considerable.

In October, 1890, I visited him at Paul Smith's, where he had located his tent, and performed a slight operation to liberate the pus on the right side above the crest of the ilium. Two years, with occasional visits to his home in Baltimore, were spent in the Adirondacks. In this time the patient was literally transformed in appearance. Weighing less than 100 pounds on arrival, he gained nearly 40 pounds from April, 1890, to November, 1891, and on his return to Baltimore he affirmed that he had never felt better in his life. His good health continuing, he became engaged, and in about two years he married. After his marriage he spent a part of two or three winters in the Adirondacks, with great benefit to his health. Occasionally I found it necessary to dilate one or more of his sinuses in order to liberate their pent-up discharges. On July 29, 1902, the patient died, the immediate cause of death being an exacerbation of the nephritis, which had existed for 12 years at least. The liver, which was very large and extended below the umbilicus at my first examination, steadily increased in size during the subsequent 12 or 13 years. In the last four or five years of his life he suffered on two or three occasions from attacks of acute nephritis, precipitated apparently by the toxaemia resulting from obstruction in one or other of the sinuses.

This was a life clearly rescued and prolonged by the Adirondacks and Dr. Trudeau. This patient had such confidence in the ability of these mountains to restore him at any time that he lived not only a most unhygienic but actually reckless life at home, repairing to Saranac Lake only when his condition sufficiently alarmed him. Three superb children survive him, to bless the Adirondacks and the physician there who made their introduction to this world possible. Consideration for his wife and children, he often told me, would not permit him to make his home in the Adirondacks. A few days after his death his sister wrote me that "of the large circle of acquaintances made in the Adirondacks, only one of those who were suffering with tuberculosis is alive today. My brother, although apparently the illest of all, survived them. In other words, I believe the treatment promises more for bone trouble than for pulmonary tuberculosis." I quote this, of course, merely to give the impression of an intelligent lay observer. That

this patient could have been rescued elsewhere than in the Adirondacks is quite likely, but having tested the mountains of Virginia, the sea coast of New Jersey and Maryland, he had faith only in the Adirondacks. One Christmas, about two years after his introduction to the Adirondacks, he returned to Baltimore, and, though wearing a heavy overcoat on a mild winter day, complained bitterly of the cold. "I am wearing today an overcoat for the first time this winter," said he, "although the thermometer has been as low as 20° below zero in the Adirondacks. Up there one is insensitive to the severest cold, but here one shivers on a mild day." His masseur, walking with him, had already made the same remark to me.

Case II.—Miss ——n, aged 15, consulted me for the first time in February, 1893. For about 18 months she had suffered with pains in her right hip and knee.

Tuberculosis on both maternal and paternal sides was conspicuous in the family history, but the patient had been perfectly healthy until the onset of the present trouble.

Examination.—Right thigh much flexed and slightly adducted. All motions of hip-joint greatly restricted. There was so much fulness about the right hip that an abscess was suspected, and a needle aimed at the joint was readily introduced into a space believed to be or to communicate with the joint cavity. The point of the needle could be moved freely, as if in an abscess, and from one and a half to two ounces of a glycerine emulsion of iodoform was at the next consultation injected without meeting resistance. Patient was kept in bed in a large, freely-ventilated room, with extension, from February until June, 1893. During these four months, five or six iodoform injections were made. After the first two or three injections it was difficult to find the abscess cavity. A light Bruns' splint was applied, and, faithfully following my urgent advice, the patient lived out-of-doors thenceforth; extension was kept up at night. For the ensuing five years she spent from six to eight hours daily in the open air. The summers of these years were lived in the low mountains near Wilkesbarre, Pa. Patient's general health was fairly good most of the time, but she was far from robust, and her appetite was unsatisfactory. The eight or ten pounds which were gained each summer in the mountains of Pennsylvania were lost in the winter.

In June, 1898, patient was admitted for a few days to my service in The Johns Hopkins Hospital, for measurements and a skiagraph. The summer of 1899 was spent at Jamestown, R. I. No gain in weight was made at the seashore and patient returned to her home near Baltimore unimproved, and out of conceit with the seaside. In January, 1900, patient was again admitted to The Johns Hopkins Hospital for careful examination subsequent to a period in which greater liberties in walking had been permitted. It was deemed wise to make an exploratory incision before permitting patient to dispense entirely with her crutches. The result of this operative examination was most satisfactory. The head of the femur had been entirely absorbed, but the neck was intact and perfectly normal, its free end occupying the remains of the acetabulum. A narrow, deep groove was cut anteriorly into the neck for its entire length, but not the slightest evidence of disease was discovered. The slight shortening which had been

observed on Bryant's line was evidently due solely to the loss of the head of the femur. The capsule of the hip-joint was intact and motion between the articulating inner end of the neck and the acetabulum was remarkable in its freedom. Nature had accomplished what a surgeon by operation could not possibly have done. A surgical operation, even the most conservative, is necessarily destructive, even if nothing more is attempted than the removal of inflammatory products or of tissues already destroyed. Patient was discharged February 7, having been detained in the hospital, after the operation, only 2½ weeks.

January 8, 1900, the day before the exploration of the hip, the red blood-corpuscles were 3,250,000; the white, 6000; the haemoglobin, 52 per cent.

January 28th, 10 days later, and 9 days postoperative, the haemoglobin was 65 per cent. February 3, haemoglobin, 65 per cent.

Comparing the measurements made by me in June, 1898, with those made independently by my house surgeon, Dr. Cushing, 18 months later, it is interesting to note that the relative differences are precisely the same. This would indicate that the disease had made no progress whatever and that the measurements were exceedingly accurate.

June 7, 1898, measurements by W. S. Halsted. Apparent difference in length of the legs, none. From anterior superior spine to trochanter, on projected vertical line:

	Left	Right
(a) Vertical line (Bryant's)	2.2 cm.	1.9 cm.
(b) Ant. sup. spine to int. malleolus	83.9 cm.	80.9 cm.
(c) Top of trochanter to ext. malleolus	84.1 cm.	81 cm.
(d) Length of femur	44.6 cm.	44.1 cm.

January 17, 1900, two days before the exploration of the hip. Notes by H. W. Cushing. Apparent difference in length, none.

	Left	Right
Ant. sup. spine to int. malleolus	83 cm.	80 cm.
Trochanter to ant. sup. spine (Bryant's line)	4.5 cm.	4 cm.

No muscle spasm. Internal and external rotation only slightly limited if at all. Extension to straight line and flexion permitted to 45° or more, notwithstanding the prolonged fixation of the joint.

The measurements indicate abduction. The apparent upriding of the right trochanter is in part due to the abduction. That there is so little measured difference (0.5 cm.) in the length of the femur, notwithstanding the growth of the patient, might suggest a thickened right trochanter. But the loss of the head of the femur, together with the abduction, should sufficiently account for the 1.9 cm. shortening in Bryant's line. How shall we interpret the fact that the difference (3 cm.) in the length of the lower extremities is almost entirely in the leg, unless we assume that the disease stimulated, as it sometimes does, the growth of the bone on its confines? The circumference of the calf was the same on the two sides, whereas there was a difference of 4 cm. in the circumference of the thighs, 15 cm. above the patella. The shortened leg was larger and the atrophied thigh was longer than expected.

From the hospital the patient went to the Adirondacks for five weeks, and while there gained 11 pounds. She learned for the first time the true meaning of living out-of-doors, and was so conscious of the great and prompt benefit received that she regretted the long doubtful years lived on the piazza at home. It is but just to myself to state that at the first consultation, and often subsequently, I had suggested and even urged the Adirondacks, but was unable, when questioned as to the relative merit of localities, to affirm that the Adirondacks alone promised relief, or more certainly promised it than the mountains elsewhere. I could only answer that the Adirondacks had been tested more thoroughly and more scientifically than any other region in this country, and, what was most important, the patient residing there would be under Dr. Trudeau's supervision, and would learn to lead the proper life.

On her return from the Adirondacks the crutches were abandoned, and our patient promptly found great enjoyment in life, riding, driving, walking, dancing, and indulging freely in the pleasures of society. Finding the out-of-door life irksome and incompatible with the new life into which, after the long confinement, she was entering so naturally and with so much relish, the hours on the piazza became fewer and fewer, until finally in the winter (1900-1901) there were none. Day after day and night after night, during this winter, our patient's strength would be tested to the extreme limit of endurance. The summer of 1901 was, in greater part, passed in Maryland. About the first of December (1901) I was consulted concerning a little swelling and a little stiffness about the right wrist-joint, which had been observed for about two months. Tuberculosis of the tendon sheaths being diagnosticated, our patient, who had lost in weight and strength, was at once admitted to The Johns Hopkins Hospital and promptly operated upon.

There was much oedema of the tendon sheaths. Fresh, translucent tubercles thickly studded the connective tissues and muscles of the forearm, particularly the tendon sheaths, from the palm of the hand to the upper third of the forearm. A very careful dissection of the tissues involved and excision of the disease was made. December 18, about two weeks after operation, the patient was discharged, and about January 1, 1902, eagerly started for the Adirondacks. Arrived at Saranac, she began to improve in health immediately, gaining 16 pounds in the first month. The remainder of this winter and the following spring were passed at Saranac, the best of health being enjoyed. The summer was spent in the Austrian Tyrol.

April 8, 1905.—Patient has enjoyed perfect health, almost without interruption, since her return to the Adirondacks in January, 1902. For the past two and a half years she has lived at her country home near Baltimore. Today she is the picture of health. The affected forearm, wrist and hand present a normal appearance, except for the scar, and perform their functions quite normally. Patient would be rarely reminded of the fact that her right hip-joint was once the site of serious tuberculous disease were it not for a very slight limp, suggesting the use of a cane when she is tired.

This case teaches us that a brief period of time is of great importance in the treatment of tuberculous joints in fast-growing children, because of the

shortening which results, particularly from disuse. In this case, the shortening from disease, represented by the difference in the height of the trochanter, is only .5 cm., whereas the difference in length of limb from trochanter to malleolus is 3.25 cm.

Case III.—Mrs. ——d. First consultation March 16, 1894. Married two years before, at the age of 26.

In November, 1894, lost a sister, aged 36, of pulmonary tuberculosis.

About the first of March, 1894, patient "felt a slipping sensation" in the right knee. History of traumatism could not be elicited. She at once consulted the late Dr. Dabney, professor of medicine in the University of Virginia, and by Dr. Dabney was referred to me.

Examination, March 16, 1894.—A delicate-looking, very slender, nervous, and emotional young woman; has always enjoyed good health until about two weeks ago, when she began to worry about her right knee. There is slight limitation of motion; a little disability; some fluid in the joint; and apparent thickening of the capsule; two or three typical tender points. The lungs and other organs are reported normal.

Diagnosis.—Tuberculosis of the right knee.

I advised Dr. Dabney to fix the knee in plaster, and to make iodoform injections into the joint, and urged the patient to lead at her home in the South the Adirondack life, which I described to her. Four injections were made by Dr. Dabney from April 7th to May 18th.

June 15th.—Second consultation. Finding the knee unimproved, I advised change of residence to the mountains, preferably the Adirondacks. Mountains near home, altitude 1900 feet, were visited, because residence in the Adirondacks was not feasible at this time. Dr. Dabney made a fifth iodoform injection, June 20th, and a sixth, July 12th. In August he died. The seventh, eighth, ninth and tenth injections were made by me in Baltimore in October and November, 1894, and January and March, 1895. About October, 1895, I advised resection of the knee, as the disease was advancing, as the patient's health was becoming decidedly impaired, and as a winter in the Adirondacks was deemed impossible by the patient and her husband. Patient returned to Baltimore, November 4, 1895, for operation. For two or three weeks patient had coughed occasionally. November 5th I carefully examined the lungs and feared that both apices were becoming involved. November 6th a second examination confirmed my fears. The operation was consequently postponed, and the patient urged to go at once to the Adirondacks. November 8th she expectorated a little blood just before starting for the Adirondacks. At this time her weight was 86 pounds. Her normal weight was about 104, and her greatest weight 112 pounds.

Soon after her arrival at Saranac Lake, Dr. Trudeau made several careful examinations and feared that the disease, although incipient, was rapidly advancing, and gave an unfavorable prognosis. For several months there was no improvement, but the patient held her own and finally began to gain in weight and in August, 1896, weighed 95 pounds. She then felt compelled to leave the Adirondacks, contrary to Dr. Trudeau's advice and my earnest solicitations. I suggested the higher mountains of western North Carolina as an alternative, but patient was so much encouraged that she decided to

go again to the mountains nearer her home in Virginia. Slowly but certainly losing ground, she eventually, in October, 1897, went to the western North Carolina mountains. Having learned in the Adirondacks how she should live and what the out-of-door life meant, she lived out-of-doors in all weathers faithfully, and became very fond of the life.

In September, 1898, I found great improvement, both in her general health and in the condition of the knee. Early in 1899 the patient's casts were discontinued. In May, 1899, patient located permanently in Hendersonville, N. C. The altitude of her private residence there is about 2250 feet. Her weight at this time was 97 pounds. Full of hope of ultimate recovery, she visited, without my consent, her relatives in Virginia in January and February, 1900, and as she wrote me, "lost considerable ground." On returning to Hendersonville, it was two or three months before she regained what she had lost.

In November, 1900, I had the pleasure of seeing my patient and finding her general condition somewhat improved and her knee disproportionately so.

January, 1901, patient writes that the knee is surely becoming less stiff.

A little later patient ventured, against my most urgent warning, another visit to her home in Virginia, to see her aged mother whose health was not good. She had an attack of "pleurisy" while at home and only with difficulty could return to Hendersonville.

Some months later, January, 1903, she writes from Hendersonville that she weighs only 85 pounds, that her "health is extremely frail," but that the knee is "vastly improved." She "can bear some weight on it" and goes "about the house with only one crutch." "Creaking and grating in the joint if exercised still noticeable to sense of hearing and touch. Motion very nearly normal."

September 28, 1903.—Met my patient, by appointment, on a railway train and examined the knee-joint. In appearance the joint, except for a very slight fulness on either side of the ligamentum patellae, showed nothing abnormal; the patient flexed and extended her knee rapidly and without the least apprehension. Flexion of the left or sound knee could be carried only 5 or 6 degrees further than of the right. There were no tender points. That such a restoration of function could take place in this knee, at one time so seriously involved, I would have believed hardly possible. It was the more remarkable because the patient's general health was very poor indeed. She was highly neurotic, suffering from tongue and stomach neurosis, and weighed only 76 pounds. I had no opportunity to examine the lungs, but was assured that she had neither cough nor expectoration, and rarely if ever had a night sweat. Her respiration was not rapid as she sat quietly in the car, nor was there anything in the voice or facies to indicate implication of the lungs.

There can be little doubt that this patient's life was saved by the Adirondacks and the North Carolina mountains. She believes that she gained much more rapidly in the former than in the latter region. The almost disastrous results of the two trips to her home in Virginia were probably not due so much to the journey, which was not a long one, as to the change of residence,

for she had repeatedly taken hard, all day drives in the mountains without demonstrable evil effects.

How remarkable, too, and significant, is the observation that, notwithstanding the gradual and great loss of strength and weight, the tuberculous process in both the knee and the lungs was not only arrested but has left no sign.

Under Dr. Thayer's care this patient has gained more than 20 pounds within a few months; he is unable to find a trace of the pulmonary disease which at one time was so active as seriously to menace her life.

Case IV.—Surg. No. 13010. Miss ——l, aged 38. First examination February 7, 1902.

Family History.—Father and mother living. One uncle and one aunt on mother's side died of pulmonary tuberculosis. A sister had a discharging sinus from one hip, but was cured while still a child. Digestion has never been very strong, and, until the age of 8, patient could not eat breakfast without vomiting immediately. At 12, her stomach performed its functions fairly well, but patient has always found it advisable to be abstemious. Has never had a chronic cough nor haemoptysis, nor observed any unusual shortness of breath. A year ago could mount ordinary hills on a bicycle without fatigue. Menses have always been regular. Has had hay-fever for 18 successive summers. Several of the finger-joints and one ankle are enlarged from "chronic rheumatism."

Present Illness.—Five months ago, in September, 1901, making a false step, patient fell backward, down three steps, striking the left hip. A slight subcutaneous extravasation of blood appeared over the left trochanter, and for about a week this bruised spot was tender. There was no limp nor pain on walking, and the incident was for the time forgotten; but about January, 1902, the left hip seemed a little stiff and occasionally felt slightly sore. These symptoms the patient tried to dissipate by walking. After about a week's exercise of this kind, a tenderness over the trochanter manifested itself. Improvement followed two days' rest in bed but, when walking was resumed, the discomfort returned. The pain, described as being dull, to use the patient's words, would "run from hip to knee," and was usually worse at night; "it felt as though a cord were stretched too tightly from the hip over the knee." A few weeks before admission, a decided limp manifested itself. Patient has never been awakened by sharp pains at night, has never had night-sweats, but for the past month has been conscious repeatedly of chilly and feverish sensations. For a year past her health has been a little below what she considered normal, her appetite has been impaired, she becomes readily fatigued, and has lost a few pounds in weight.

February 12, 1902. Physical Examination.—Patient is a slender, delicate-looking woman, but is tall, erect and well formed. Thorax and abdomen negative. The inguinal glands are very slightly enlarged on both sides.

The Hips.—Inspection reveals a very slight apparent shortening of the left leg, possibly 0.5 cm., and little else. The back is flat, and there seems to be no abnormal flexion of either hip.

Measurements by the House Surgeon

Ant. sup. spine to ext. mall.	Trochanter to mall.	Ant. sup. spine to trochanter
Left side, 85 cm.	81.5 cm.	3.7 cm.
Right side, 85 cm.	81.5 cm.	3.2 cm.

The 0.5 cm. difference in the length of Bryant's line, if correct, I believed to be due, in part at least, to the abduction of the right and adduction of the left leg.

All the motions of the affected left side seem to be normal if they are made gently and with suitable traction. Even sudden motions are not definitely resisted, except abduction and extreme adduction and internal rotation. Flexion and extension are perfect. Hyperextension seems about equal on the two sides.

Except for the apparent shortening (adduction), the slight rigidity of the adductor muscles, and the tenderness over the trochanter, there are no definite signs of irritation in or about the left hip-joint. There seems to be a little thickening of the left trochanter.

Measurements made by the writer differed in no essential particular from those given above. To determine accurately the distance from the top of the great trochanter to the malleolus, a tape measure seems to the writer to be unreliable, because one cannot make proper allowance for the distance the muscles permit one's finger on each side to press in over the trochanter toward the digital fossa. With a wooden measure, which we have constructed somewhat on the plan of a shoemaker's foot rule, this source of error is excluded.

April 11, 1902.—Examination by writer. (a) Apparent shortening, 1.3 cm.; gluteal fold, 1 cm. lower. (b) From spine to top of trochanter on projected vertical line (Bryant's), no shortening. (c) From anterior sup. spine to ext. malleolus, no shortening.

Rotation out 6° to 7° less on left than on right side. Rotation is about 4° less on left than on right side. Adduction very slightly restricted, hardly demonstrable; rigidity of adductor muscles. Flexion and extension normal. Possibly slight impairment of hyperextension. Exceedingly indefinite reaction to 2 mg. and 4 mg. of tuberculin. After 9 mg. of tuberculin, the temperature rose to 101° F., and patient complained slightly of headache and general malaise. The tuberculin at this particular period happened to be weaker than usual, and 9 mg. was a not uncommon dose. Patient was discharged today, having been under observation for 63 days. Treatment, extension by weights and pulley at night, and brace during the day.

The days were passed on the bridge. Patient intended to continue in all its details the treatment instituted. This she did most conscientiously and intelligently under the care and heartiest cooperation of Dr. Joseph S. Miller, but as she has since then repeatedly assured me, she had no conception of the true out-of-door life as it is lived in the Adirondacks under Dr. Trudeau's supervision.

October 30, 1902.—Readmitted to hospital for examination. Since first visit has had very little pain in hip in the day time, but at night has been occasionally awakened by it, particularly by sudden jerkings.

Examination, November 6, 1902.—The motions at the hip-joint are decidedly less free than at first examination, eight months ago. Flexion, which was then about normal, is stopped at 85°. Rotation, in both flexed and extended positions, is much restricted, particularly rotation outward. There is pronounced spasm of the adductors now, whereas at first rigidity was barely demonstrable. The trochanter is more sensitive to pressure, particularly behind just below the posterior superior angle and along the posterior surface. The circumference of both thigh and calf is 6 cm. less on left side. Four milligrams of tuberculin produced marked general reaction and temperature of 102° F. The change for the worse in the local and also general condition is so definite that our patient decided, without hesitation, to go at once to the Adirondacks.

March 20, 1903.—Readmitted to the hospital for examination after a winter in the Adirondacks. The change in patient's general appearance is very striking, although she has gained in weight only five pounds. From the appearance of her face and neck and body I was quite sure the gain in weight had been greater. Patient's voice is stronger and her flesh much firmer. There has been of late no pain whatever in the hip, and rarely any discomfort.

Measurements.—Apparent shortening .5 cm. Flexion permitted easily to right angle is checked only by stiffened knee. Inward rotation about equal on the two sides. Outward rotation less by 3° to 5° on affected side. Abduction limited about 2°. Adduction same on both sides. There is no fixed flexion. No riding up of trochanter; indeed, it is a little lower perhaps (adduction) on the left side. Hyperextension not permitted.

November 15, 1904.—The 18 months since the previous examination have in greater part been spent in the Adirondacks. Six of these months, lived at home, seemed to result in no improvement, although patient faithfully carried out the Saranac regime. The local improvement is so definite that I have decided to permit patient to discard the brace and to walk a little on the affected leg, notwithstanding a definite reaction, both general and local, to 2 mg. of tuberculin. The rise in temperature, however, was very little, only to 100.5° and sustained for less than two hours. It then dropped promptly to normal.

Examination.—There is now for the first time no apparent shortening and only the slightest rigidity of the adductor muscles. The difference in the motions of the right and left hips is too indefinite to be recorded. Patient has complained a little of late of peculiar feelings in both hips, somewhat "rheumatic" in character, and rather more pronounced in the right than left hip. During the past year she has had two or three rather severe attacks of indigestion.

March 7, 1905.—Since last examination and discarding of the brace the patient has been getting on famously, notwithstanding a severe fall on the affected hip a few weeks ago. She has gained three to four pounds in six months, which is a great deal for her. Altogether the gain in weight since patient first consulted me has been 17 pounds. The entire three years, except the nights, have been lived out-of-doors. The crutches are now discarded and the patient is permitted to walk with only a cane.

The lessons taught by the forecited cases, especially the later ones, can hardly fail to awaken positive enthusiasm in others as it has in us. The recent observations tinge, however, the retrospect with regret that we could not have foreseen the great advantage—I hardly venture to say necessity—of the night out-of-doors, as well as the day. The cases, Nos. VII, VIII and IX, which have made the most rapid strides are those which have slept out-of-doors, and, curiously, happen to be those which were not treated in the Adirondacks or any sanatorium. These are the only patients of the series who have spent the entire 24 hours in the open. In one, Case VII, a month of this life in Virginia sufficed to dissipate completely a large mass of tuberculous glands in the unoperated side of the neck. Case VIII, one of knee-joint tuberculosis, conveys, it seems to me, a very significant lesson. After a winter in the Adirondacks, the entire day out-of-doors, and a gain in weight of 19 pounds, little if any local improvement was demonstrable. It is quite likely, however, that we were unable to interpret properly, or even to discover the local changes. But after a few months, only three or four of the night and day treatment in the heat of midsummer in Montgomery, Ala., complete recovery and almost complete restoration of function have taken place. It seems to be a fact that most tuberculous patients who are taking the out-of-doors treatment under advisement progress more rapidly in cold weather than in hot, and our patient tells us that the weather in Montgomery was hot, at times very hot, while he was there in the open, night and day.

In Case IX, three months of the 24-hours-a-day treatment, on the coast of Maine, dissipated a mass of actively inflamed and softened glands of the neck, the skin over which had rapidly reddened and thinned during the 6-hours-a-day treatment at the seashore further south.

I shall say nothing about *climate,* not even discuss the relative merits of localities. I am merely emphasizing the importance for some patients of the 24-hours-a-day out-of-doors. When the thermometer registers 20° below zero, a night out-of-doors is not an agreeable prospect, and may be a difficult problem; and so occasionally there might arise the question, Is it better to have from 8 to 10 hours of the day in the open in a cold climate or 24 hours in a more temperate one?[5] The advantages of a speedy recovery are so evident that they need not be urged. A rapidly growing boy with tuberculosis of the knee-joint might lose a great deal in the length of the affected

[5] In the recital of Case III, describing the almost disastrous effects upon this patient of visits from the North Carolina mountains to her home, I may have conveyed the impression that a certain part of Virginia is unsuitable for tuberculous patients. But here the fatigue of the railroad journey, the excitement of seeing friends constantly, of living with relatives, and perhaps numberless little things may have been responsible for the serious interruptions of the convalescence.

limb unless the cure were rapidly effected. I have had such a case under observation. The proper treatment of this case was attended with such difficulties that I consented to a modified and less rigorous form of life out-of-doors. The disease made no progress and in less than four years seemed cured, but the boy had, in the meantime, grown perhaps 9 or 10 inches. The affected epiphyses had not kept pace with the normal ones on the opposite side and the boy has perhaps 5 inches shortening and incomplete mobility. If I could have foreseen such excessive growth or had known the merits of the 24-hour day, I must have insisted upon the full time in the open.

Furthermore, the prospect of *years* of treatment, in a sanatorium, or away from home, or at home on a roof in the city, or simply camping day and night in the country, is dispiriting and not readily consented to by patients or friends. But a few months or a year of such a life, coupled with almost a guarantee of recovery might be anticipated with relish, and regarded as an outing combining duty and pleasure and immeasurable profit.

I shall be much interested to learn the present views of Dr. Trudeau and others upon the relative value of localities. Several of my patients who had faithfully lived out-of-doors, at home and abroad, showed the first positive signs of improvement, both general and local, after a winter in the Adirondacks. Dr. Trudeau, in one of his letters to me many years ago concerning my patients at Saranac, exclaims: "The more I go, the more convinced I am that it is of little use merely to tell people to live out-of-doors. They must be provided with accommodations which enable them to live out-of-doors easily and comfortably. Special buildings must be planned and constructed for the purpose. Some day you will have to carry into effect your plans for an infirmary for cases of surgical tuberculosis. These patients should sleep out-of-doors all night and live out-of-doors all day, being provided with every comfort and convenience." And several of my patients, after living awhile at Saranac Lake, have written to me that, notwithstanding the most detailed instructions from me and from patients who had taken the Adirondack cure, they had not until then learned the true meaning of the real life out-of-doors. One should, if possible, have the benefit of the proper influences, of place, of people, and, most important, of the true physician, in order to acquire the stimulus necessary to the faithful carrying out of the treatment.

I should have the greatest confidence in the efficacy of massage in the treatment of these cases.

And as to the diet, is it necessary or wise to stuff our patients? A non-tuberculous individual is usually more vigorous if he is not overfed. There is at least opportunity for the exercise of considerable discretion in the matter of feeding. I have particularly in mind a wealthy child, whose days

were spent out-of-doors, and who developed tuberculous glands, notwithstanding a huge appetite and the liberal indulging of it; and another, reported in this series, whose seriously involved knee and lungs recovered completely, notwithstanding a gradual loss of weight from 104 to 76 pounds.

Tuberculin, which for nearly 14 years has been our main reliance for diagnosis, has never assisted us in deciding when to discontinue fixation and to permit use of the affected joint. A definite reaction could probably be obtained today in all of our "cured" cases. We have in no instance failed to get this reaction when crutches were about to be discarded, and in two individuals it was prompter on release from the treatment than at its institution.

That most cases of surgical tuberculosis will recover without operation if they are given a fair opportunity in the open air, I am convinced, nor should I be surprised if it proved to be, in general, an easily curable disease. My hardest task in the treatment of these cases has been to persuade the relatives and friends and, alas, the physicians of patients, of the necessity of taking so much trouble, of instituting a disturbance of the even tenor of the family's existence or of involving themselves in such unanticipated expenditure. I have submitted the pros and parried the cons with the parents for hours, and until so weary of the battle that I have vowed never again to misplace so much energy. But interest in the subject, as great occasionally as in the particular patient, has usually stimulated a renewal of the attack.

Unless acquainted with the lamentable results usually obtained in the treatment of cases such as these herewith presented, one can hardly comprehend what has been accomplished by the open-air treatment of them and realize what assurances it holds for the future. How eagerly we should welcome an achievement which properly curtails the indications for the practice of surgery, a therapeutic measure so crude and often so mutilative. In the huge multitude of cripples from the ravages of tuberculosis we find overwhelming proof of the inadequacy of past and present methods of treatment. How different is the story just related. In not one instance did the disease make the slightest appreciable advance after the treatment was inaugurated. The restoration of function is perfect in all save one (*Vid.* Case II) and in this it is excellent. Had this patient been given the benefit of the night as well as the day out-of-doors the treatment, begun in 1892, might have terminated in one year or two instead of seven.

Great interest is now being manifested abroad in the fresh air treatment of children afflicted with surgical tuberculosis, but of its power for the cure of this disease there appears to be only a meagre conception, the treatment consisting, as a rule, of a very free circulation of air through the wards in

the day time, but not at night. The importance of *rapid cures* has not been emphasized, nor has the possibility of such marvelously prompt results as *the continuous out-of-door treatment* furnishes, been recognized.

The surgeon's duty is not done when he advises his tuberculous patient to live out-of-doors. He must, if the patient's means permit, and if other localities promise decidedly more than home, send him away and entrust him to a physician or companion who will assume the responsibility of insuring a continuous out-of-door life.

Public opinion, which has compelled the sceptical physician to transfer his case of appendicitis to the proper surgeon, will soon hold the surgeon responsible for bad or even indifferent results in tuberculous disease of the hip, the knee, the peritonaeum.

The work of Dr. John W. Brannan and his associates in establishing and conducting the Sea Side Hospital for Children on Coney Island deserves the fullest recognition and encouragement.

The literature pertaining to this subject was admirably presented by Dr. Herbert L. Burrell, in a discourse at the annual meeting of the Massachusetts Medical Society, June 10, 1903.

DISCUSSION

We use Dr. Trudeau's preparation and method, employing two milligrams to begin with in an adult, and one milligram in children, increasing the second dose to four milligrams. A third dose is very rarely needed.

CONDUCTION ANAESTHESIA

PRACTICAL COMMENTS ON THE USE AND ABUSE OF COCAINE; SUGGESTED BY ITS INVARIABLY SUCCESSFUL EMPLOYMENT IN MORE THAN A THOUSAND MINOR SURGICAL OPERATIONS

WATER AS A LOCAL ANAESTHETIC[1]

While this article (*N. York M. J.,* 1885, xlii, 294-295) is the first publication by Dr. Halsted, himself, on the subject of cocaine anaesthesia, its republication is here omitted as this would require such reediting as is not deemed expedient, the article itself having been written while Dr. Halsted was ill. Previous to the publication of this article, two papers had appeared establishing Dr. Halsted's priority in the use of this surgical procedure. The first of these is by Dr. R. J. Hall, who at that time was an assistant of Dr. Halsted at the Roosevelt Hospital Dispensary, and appears in the *New York Medical Journal,* December 6, 1884. The second paper, entitled "Hydrochlorate of cocaine as a local anaesthetic in Dental Practice" (*Dental Cosmos,* Phila., 1885, xxvii, 208-209), is by Dr. E. H. Raymond, who reports the case of a Dr. John M. Woodbury, whose very sensitive tooth was filled painlessly after typical blocking of the inferior dental nerve by Dr. Halsted in December, 1884.

Dr. Halsted's first published statement regarding local anaesthesia by water-infiltration of the skin appeared in a letter dated September 16, 1885 (*N. York M. J.,* 1885, xlii, 327), from which the following essential statements are quoted:

"1. The skin can be completely anaesthetized to any extent by cutaneous injections of water.

"2. I have at times, of late, used water instead of cocaine in minor operations requiring incision.

"3. The anaesthesia seldom oversteps the boundary of the original bloodless wheal, but does not always vanish just as soon as hyperaemia supervenes."

The following letter by Dr. R. J. Hall is here quoted in full from the *New York Medical Journal,* 1885, xl, 643, because it is the first published account of Dr. Halsted's early work:

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[1] Under the original title of Dr. Halsted's first publication the editor has placed the collected evidence of Dr. Halsted's pioneer work, including the discovery of the local anaesthetic action of water.

N. York M. J., 1885, xlii, 294-295.

"HYDROCHLORATE OF COCAINE

"17 East Forty-Ninth Street, November 26, 1884.

"*To the Editor of the New York Medical Journal:*

"SIR.—Wishing to use the hydrochlorate of cocaine in some small operations at the Roosevelt Hospital Out-Door Department, I made some experiments on myself to determine the best mode of using it. The preparation was a 4 per cent solution made by Parke, Davis & Co. Injecting subcutaneously six minims on the dorsal surface of the forearm, at the junctions of the middle and upper thirds, near the ulnar border, caused complete loss of sensation over an area extending *downward* as far as the lower end of the ulna, from three quarters of an inch to an inch wide above, and half an inch wide below, obviously following the distribution of a cutaneous branch of the ulnar nerve. There was no diminution of sensibility above the point at which the needle was introduced. A number of subsequent experiments showed that the anaesthesia extended over the region supplied by the cutaneous nerves near or into which the injection was made. Thus, in a number of experiments made by Dr. Halsted and myself, we have found that, injected subcutaneously into the leg or forearm, not in the neighborhood of any large nerve-trunk, it will cause anaesthesia for a distance of two or three inches below the point of injection. An injection into the musculocutaneous nerve of the leg, at the point where it pierces the deep fascia, caused anaesthesia over all that portion of the leg and foot supplied by this nerve. An injection of eight minims into my left ulnar nerve at the elbow had no effect. An injection of thirty-two minims into the right ulnar nerve at the elbow caused, in two or three minutes, numbness and tingling down the forearm and little finger, and in five or six minutes anaesthesia extending down the ulnar border of the forearm and hand and over the little finger, with much reduction of the sensibility on the ulnar border of the ring-finger. There was an anaesthetic area over the olecranon and the posterior surface of the external condyle, which we should not expect to be supplied by the ulnar nerve. There was no apparent diminution of muscular power, and no anaesthesia of the skin at the point where the injection was given. We have noticed that, when the needle is thrust into the deeper layers of the subcutaneous connective tissue, there is usually no loss of sensibility at the point where the needle was introduced.

"With the anaesthesia, marked constitutional symptoms appeared; about six minutes after the injection there was giddiness, at first slight, then well marked, so that I could not walk without staggering; and finally there was severe nausea, which would have been much worse, I think, had not the stomach been empty. At the same time, the skin was covered with cold perspiration, and the pupils were dilated. The nausea passed off, with the local anaesthesia, in about twenty minutes, leaving some dizziness for an hour or so longer.

"The same evening Dr. Halsted removed a small congenital cystic tumor, situated directly over the outer third of the left supraorbital ridge, and believed to be a meningocele, the communication of which with the cranial

cavity had been shut off. Nineteen minims of the 4 per cent solution were given hypodermically in divided doses, one external to the tumor, and the others close to the supraorbital notch. In about five minutes the anaesthesia was complete. The incision through the skin and the earlier steps of the operation were not felt at all, but, in consequence of the close adhesions of the sac and its extensive prolongations, especially into the upper lid, the operation was somewhat protracted, and the anaesthesia had passed off to a considerable extent before it was completed. I was informed of a case, occurring on the same day, in which cocaine was injected, preparatory to performing a small plastic operation, in the same region, but no anaesthesia of the field of operation was produced. On inquiry, I was told that the injections had been given *above* the point where the incisions were to be made.

"This afternoon, having occasion to have the left first upper incisor tooth filled, and finding that the dentine was extremely sensitive, I induced Dr. Nash, of No. 31 West Thirty-First Street, to try the effects of cocaine. The needle was passed through the mucous membrane of the mouth to a point as close as possible to the infraorbital foramen, and eight minims were injected. In two minutes there was complete anaesthesia of the left half of the upper lip and of the cheek somewhat beyond the angle of the mouth (as I was in the dentist's chair, I could not determine the exact limits), involving both the cutaneous and the mucous surfaces; also of the left side of the lower border of the *septum nasi* and of the anterior surface and lower border of the gums, extending from the median line to the first molar tooth. Forcing the teeth apart with a wedge caused no pain except when the wedge impinged on the unaffected mucous membrane of the posterior surface of the gums. Dr. Nash was then able to scrape out the cavity in the tooth, which had previously been so exquisitely sensitive, and to fill it, without my experiencing any sensation whatever. The anaesthesia was complete until twenty-six minutes after the injection, and sensibility was much diminished for ten or fifteen minutes longer. Piercing the mucous membrane with the needle caused pain like the prick of a pin, but its subsequent introduction until it struck the bone and the injection of the solution were not felt. In the same way, the introduction of the needle into the ulnar nerve caused quite severe pain, with tingling down the little finger, but the injection of the fluid gave rise to no sensation. In the experiment on teeth, it surprised that the incisor tooth should be rendered insensitive, as the anterior-superior dental nerve is given off in the infraorbital canal. I can only suppose that the effect extends some distance along the nerve centrally, or that the fluid travels along the sheath of the nerve into the canal.

"We have already used this mode of administration successfully in a number of cases in the Roosevelt Hospital Out-Door Department, and it is obvious that when the limits of safety have been determined it may find very wide application. For instance, in addition to the usual application to the conjunctiva, in operations on the eye, an injection into the orbit, in the neighborhood of the ciliary nerves, would doubtless diminish the liability to a very grave accident, which I understand, has already occurred several times in the city—namely, in extrusion of the lens, from blepharo-

spasm, occurring during iridectomy performed with the aid of cocaine. We have injected twenty minims a number of times, without causing any constitutional symptoms.

"Very truly yours,
"R. J. Hall, M. D.

"*Postscript, December 1st.* Since the foregoing was written we have made some additional experiments which seem of interest. Dr. Halsted gave Mr. Locke, a medical student, an injection of nine minims, trying to reach with the point of the needle the inferior dental nerve where it enters the dental canal. In from four to six minutes there was complete anaesthesia of the tongue, on the side where the injection had been given, extending to the median line and backward to the base as far as could be reached with a pointed instrument. There was further complete anaesthesia of the gums, anteriorly and posteriorly, to the median line, and all the teeth on that side were insensitive to blows. The soft palate and uvula, on the same side, were anaemic and quite insensitive. Mr. Locke thought also that there was some diminution of sensibility in the domain of the auriculo-temporal nerve.

"In four or five other cases where the injection was made in the same way, from fifteen to twenty minims being used, the fluid seemed to have come nearer the lingual than the inferior dental. In all, the tongue was affected sooner than the gums; the anaesthesia extended as far back as the epiglottis, and the sense of taste was abolished on the affected side; and the posterior surface of the gums was earlier and more completely anaesthetized than the anterior.

"This evening Dr. Halsted gave me an injection of seventeen minims, the needle being introduced along the internal surface of the left ramus until it touched the inferior dental nerve, causing a sharp twinge along the whole line of the lower teeth. In three minutes there was numbness and tingling of the skin, extending from the angle of the mouth to the median line, and also of the left border of the tongue. In six minutes there was complete anaesthesia of the left half of the lower lip, on both the cutaneous and mucous surfaces, extending from the median line to the angle of the mouth and downward to the inferior border of the jaw. A pin thrust completely through the lip caused no sensation whatever. There was also complete anaesthesia of the posterior surface of the gums and of the lower teeth on the left side, exactly to the median line; hard blows upon the teeth with the back of a knife caused no sensation. The anterior surface of the gums was anaesthetic only from the median line to the first bicuspid. There was a small area of complete anaesthesia about the middle third of the left border of the tongue, not more than an inch in diameter. A slight return of sensation began twenty-five minutes after the injection and five minutes later no complete anaesthesia remained anywhere. I should mention that fifteen to twenty minims in this region caused, in two or three cases, slight constitutional symptoms similar to those previously described."

The following article by Dr. E. H. Raymond is here quoted from the *Dental Cosmos,* Phila., 1885, xxvii, 208-209, because it is the second published account of Dr. Halsted's early work:

"HYDROCHLORATE OF COCAINE AS A LOCAL ANAESTHETIC IN DENTAL SURGERY

"The New York Odontological Society held a regular monthly meeting at the house of Dr. W. E. Hoag, No. 13 East Forty-Third Street, January 20, 1885.

"The President, Dr. William Jarvie, in the chair.

"*President Jarvie.*—Gentlemen, as you all know the experiments that have been and are in the course of being made with cocaine are attracting a great deal of attention. Dr. Raymond has been studying this matter recently, and he will give us his experiences.

"*Dr. E. H. Raymond.*—This brings me to the citation of cases of successful practical experimentation, which demonstrates this fact, *by bringing the agent in contact with the nerve trunk you will get partial if not total insensibility throughout its ramifications.* Early in December while attending Dr. John M. Woodbury of this city, professionally, the subject of cocaine was mentioned. He informed me that he and several of his friends had used it in minor surgical operations by injecting it on the nerve supplying sensation to the part to be operated on. As he had a very sensitive cavity to be filled in a molar, I suggested the idea of his being injected with the cocaine, so that we might test the drug and its effect upon the tooth. He willingly assented. We accordingly went to the office of his friend, Dr. Halsted, who injected the drug with the following result:

CASE I.—Dr. W.; cavity on the posterior surface of the right inferior first molar; excessive sensibility on touching it. Caries had not caused much loss of the dentine covering the pulp. That organ was well protected and in a normal condition. The syringe was charged with thirteen minims of a 4 per cent solution of cocaine, and the needle-point directed on a line extending about midway between the angle and the coronoid process of the inferior maxillary, passing through the internal pterygoid muscle. The finger being placed upon the internal oblique line as a guide, the syringe-needle was carried along the inner surface of the ramus until it reached the nerve as it enters the inferior dental foramen. A "tingling" sensation was produced in the bicuspids and incisors when the syringe was discharged. In three minutes the tongue began to feel thick and numb on the right side. In seven minutes there was almost complete anaesthesia of the right half of the tongue and the gums around the inferior teeth. The excavator being applied to the cavity which was previously so tender, no sensation whatever was felt by the patient. I then used the engine with perfect freedom, and prepared the cavity for filling without any discomfort to him. Although there was just a slight degree of sensibility in the bottom of the cavity, he said it amounted to nothing comparatively; he was just conscious that the instrument was there. The gustatory nerve, which lies near the inferior dental at the point injected, accounts for the tongue being anaesthetized. As the gustatory was not touched, this shows that it is not necessary for the needle to

penetrate the nerve-substance. The cervical portion of the cuspid on the left side was very painful to touch, owing to denudation of the soft tissues that covered it; but, while operating on the side injected, the cuspid, although being in the same condition as the other, could be rubbed with a steel instrument without the slightest manifestation of pain. The anaesthesia lasted for about twenty-eight minutes, when normal sensibility returned. That evening at dinner there was some stiffness and a slight soreness in the muscles while masticating on the right side. The next morning there were no symptoms indicating that he had submitted to any unusual treatment."

Two previously unpublished letters of Dr. Halsted to Dr. C. E. Kells contain further description of his work and are here quoted:

"March 29, 1920.

"*Dr. C. Edmund Kells, 1237 Maison Blanche, New Orleans, La.:*

"DEAR DR. KELLS.—I am very appreciative of Dr. Matas' kindness in telling you of our early work with cocaine and take pleasure in complying with your polite request for further details.

"Dr. Richard Hall died many years ago in Los Angeles or Santa Barbara. Hall and I were studying in Vienna in 1879 and 1880, and later were intimately associated in surgical work at the Roosevelt Hospital and in its Out-Patient Department, he being my first assistant, Frank Hartley, the second, and Frank Markoe, the third. Dr. George Brewer of New York was also an accomplished member of my staff in this dispensary.

"Within a week or two, at most, of the arrival in this country of Koller's first paper announcing the anaesthetic effect of cocaine on the conjunctiva we began active experimentation with this drug, hoping that it might prove of use in general surgery. By "we" I mean twenty-five or thirty students of the College of Physicians and Surgeons (Columbia), all having the B. A. degree, who registered with me as their preceptor. At the evening quizzes we began our injections into nerves, almost all of the accessible nerves being tested—the inferior dental with the rest.

"Dr. Thomas A. McBride, a remarkably gifted physician with a large consulting practice, referred to me, in the winter of 1884 and 1885, the wife of a wealthy and prominent citizen. She was a sufferer from trigeminal neuralgia, the pain being pretty well confined to the region supplied by the third branch. I decided to perform the Paravicini operation under local anaesthesia and designed a very broad clamp with which to seize the nerve. The purpose of the unusual breadth of the instrument was to insure the excision of a long piece of the inferior dental nerve.

"The operation was performed in a bedroom of my house, the patient being assured that she could return home the same afternoon. I was assisted by Dr. Richard Hall and Dr. Frank Hartley. The nerve having been satisfactorily anaesthetized central to the inferior dental foramen with a 4 per cent solution of muriate of cocaine, was exposed and seized with the broad clamp without great difficulty. With a scissors I divided the nerve at the distal edge of the clamp. Then, guided only by the clamp and a finger, I made a snip with the scissors, in the deep hole, through the nerve at the central edge of the clamp. Thereupon there was a great gush of arterial

blood—so great I thought that the internal maxillary artery must have been cut. The patient was in danger for a moment of being suffocated with blood. By forcible packing with iodoform gauze the haemorrhage was stopped, but such pressure was made by the packing that I feared extensive sloughing of the soft parts might ensue. Confidently expecting a recurrence of the bleeding, I hastily summoned two trained nurses from the Presbyterian Hospital and had the patient put to bed in my house. In a day or two she was transferred to the Presbyterian Hospital. There was no recurrence of the bleeding.

"About the eighth day after operation and with considerable apprehension I cautiously removed the gauze packing. The patient recovered without a complication of any kind.

"Strange to say, I did not know that Hall had reported this case until in 1914 at a meeting of the Deutsche Gesellschaft für Chirurgie Professor Rehn, the President of the Congress, referred to it in the course of a discussion. From him I obtained the reference to Hall's paper. I believe that Braun mentions it in his book on local anaesthesia.

"Hall was appointed professor of anatomy at the Columbia Medical School, but on account of ill health he soon resigned. He became a successful and highly esteemed practitioner of surgery in Santa Barbara or Los Angeles. Dr. George Woolsey and Dr. Lucius Hotchkiss and other students of mine in New York could tell you something of our early experiments and operations with local anaesthesia.

"I published at the time a few little paragraphs on the subject in the New York Medical Journal. One of these was to call attention to the fact that one could produce local anaesthesia with injections of water. We soon discovered that very dilute solutions of cocaine sufficed, and in the first years of The Johns Hopkins Hospital I made extensive use of local anaesthesia with these very mild solutions—as weak sometimes as one to ten thousand.

"Already in 1884 I had noted the effect of anaemia on the anaesthetized parts, and emphasized the importance of distending the tissues until they were blanched. I made use of the constricting rubber bandage on the limbs and of heavy rubber rings on the fingers in order to intensify and prolong the action of the drug. When small veins were accidently injected we observed the production of urticaria-like wheals.

"In the fall of 1885 I had a few amusing experiences with the dentists in Vienna. Having occasion to consult Dr. Thomas, a famous 'American dentist,' with spacious offices in the 'Graben,' I demonstrated to him the effects of injecting the inferior dental nerve. His first assistant was so impressed that he requested me to inject his nerve, and thereupon asked Dr. Thomas to pull one or two roots and fill a tooth. Professor Anton Wölfler, the first assistant of Billroth, published during this visit of mine to Vienna a brief note on the subject of cocaine anaesthesia in one of the Vienna morning papers, based on a demonstration which I had given him a day or two before of our method of using it for surgical operations. Prior to this demonstration he had convinced himself by experimentation that cocaine would not produce anaesthesia except on the surface of mucous membranes—that it was useless when injected into the tissues.

"I beg that you will pardon me for indulging in such a lengthy reminiscence.

"Will you give my kind regards to Dr. Matas.

"Very truly yours,
"WM. S. HALSTED."

"BALTIMORE, October 26, 1920.

"*Dr. C. Edmund Kells, 1237 Maison Blanche, New Orleans, La.:*

"DEAR DR. KELLS.—In reply to your question I may say that Koller was the first to inject the infraorbital nerve, but my experiments on nerve blocking antedate his. I practised blocking almost every nerve which we thought could be reached with the needle (roots of the brachial plexus, sciatic, and particularly the subcutaneous nerves) and performed many minor and some major operations with local anaesthesia (excision of axillary glands, resection of elbow, amputations, etc.).

"With kind regards, I am,

"Very truly yours,
"WM. S. HALSTED."

The following paragraphs from a letter of Dr. Halsted to Dr. Matas contain further statements of Dr. Halsted on local anaesthesia:

"May 30, 1921.

"*Dr. Rudolph Matas, 2255 St. Charles Ave., New Orleans, La.:*

"MY DEAR MATAS.—You can well believe that after discovering the anaesthetic properties of water—which I attributed largely to anaemia produced by it—that I should have immediately experimented with very dilute solutions of cocaine. The intradermal injections were made with the intention of producing anaemia, and we were guided then as today in making our incisions by the anaemic appearance of the skin distended by the injected fluid.

"Ever yours,
"WM. S. HALSTED.

"*P. S.* One of the major operations performed by me under cocaine anaesthesia during the winter of 1884-1885 was the freeing of the cords and nerves of the brachial plexus after injection of the roots of this plexus. This operation was performed in a large tent which I built on the grounds of Bellevue Hospital, having found it impossible to carry out antiseptic precautions in the general amphitheatre of Bellevue where the numerous anti-Lister surgeons dominated and predominated."

The following extract from a letter of Dr. Rudolph Matas of New Orleans to Dr. Willard Bartlett is quoted because it clearly states the judgment of an eminent American surgeon and authority, who made a thorough study of the question of priority in the introduction of conduction surgical anaesthesia. Dr. Matas, a lover of justice and historic accuracy, considers that "Dr. Halsted's just right to recognition as the first to discover and apply the facts that are at the present time fundamental in regard to local and

regional anaesthesia, nerve blocking, or socalled conduction anaesthesia (Leitungs Anesthesia) should be given the recognition they deserve, especially from his American colleagues." Dr. Matas' communication is included in Dr. Bartlett's Presidential Address before the Southern Surgical and Gynecological Association, "An estimate of the value of local anaesthesia in the surgery of today" (Tr. South. Surg. & Gynec. Ass., Phila., 1920, xxxiii, 2-3):

"Dr. Halsted's work began almost immediately after Koller had made his epochal announcement of the anaesthetic practice of cocaine on the eye, at the Heidelberg Ophthalmologic Congress in September, 1884. He set to work at once at the Roosevelt Hospital, and before December, 1884, had discovered at least three, if not four, fundamental facts, which he demonstrated experimentally and clinically, in which he antedated *all* other investigators.

"The discoveries are: (1) The *intradermal* as distinguished from the subcutaneous method of infiltration; (2) the value of water as a local anaesthetic and of the *efficiency of very dilute analgesic solutions,* in which he antedated Schleich by at least four years; (3) the *neuroregional method,* or regional anaesthesia by nerve blocking, which he clearly demonstrated by blocking the inferior dental at the spine of Spix, and thus obtaining complete anaesthesia of the teeth of the lower jaw, which permitted the painless extraction of the teeth. See Hall's letter in the *New York Medical Journal* for December 6, 1884, and Raymond's report, New York Odontological Society, 1885 (*The Dental Cosmos,* Phila., 1885, xxvii, 208), who describe a painless operation on the teeth, in December, 1884, after Halsted had injected the inferior dental at its entrance into the inferior dental canal. On all these points there can be no question of his right to priority, and I also believe that he was the first to note; (4) the prolongation of the anaesthetic action of the drug by circular constriction and retardation of the circulation in the infiltrated area."

The following comprehensive bibliography, which was prepared by Dr. Rudolph Matas of New Orleans, so clearly presents the evidence of the priority of Dr. Halsted's work that it is deemed important to include it. The editor has added several references.

1. Koller, K. Vorläufige Mitteilung über local Anästhesirung im Auge. XVI. Ophthalmologen Kongress. Heidelberg, Sept., 1884.

2. Koller, K. Ueber Verwendung des Cocain zur Anästhesirung am Auge. Wien. med. Woch., 1884, 1276-1278; 1309-1311.

Also: Translated into English by H. Knapp and published in, "Cocaine and its use in ophthalmic and general surgery" by Hermann Jakob Knapp, M. D., New York & London, G. P. Putnam's Sons, 1885, pages 1-9.

3. Hall, R. J. Hydrochlorate of cocaine. A letter to the Editor of the New York Medical Journal, December 6, 1884. N. York M. J., 1884, xl, 643-644.

(In this is the first account of Halsted's experimental and clinical demonstrations in dental and oral practice following a few weeks after Koller's publication in the Wien. med. Woch., 1884.)

4. "The new local anaesthetic." An editorial in the New York Medical Journal, December 6, 1884, xl, 641.

(In this editorial Halsted's and Hall's first experiences in regional anaesthesia and nerve blocking are related and fully credited.)

5. Raymond, E. H. Hydrochlorate of cocaine as a local anaesthetic in dental surgery. Tr. N. York Odontological Soc., 1885. (Philadelphia, 1886.)

Also: Dental Cosmos, Phila., 1885, xxvii, 208-209.

(In this an account is given of the case of Dr. Woodbury who had a very sensitive cavity filled painlessly after a typical blocking of the inferior dental nerve by Dr. W. S. Halsted. This was done in December 1884, a little over two months after Koller's first publication had reached this country.)

6. Halsted, W. S. Practical comments on the use and abuse of cocaine, suggested by its invariably successful employment in more than 1000 minor surgical operations. N. York M. J., 1885, xlii, 294-295.

(This is only the first part of a paper which was intended to review Dr. Halsted's work from October, 1884, to the date of publication, but was never completed on account of Dr. Halsted's illness.)

7. Halsted, W. S. Water as a local anaesthetic. A letter to the Editor. N. York M. J., 1885, xlii, 327. September 19th, 1885.

8. Knapp, H. J. Cocaine and its use in ophthalmic and general surgery.

In: Cocaine and its use in ophthalmic and general surgery, by Hermann Jakob Knapp, M.D., New York & London, G. P. Putnam's Sons, 1885, pages 27-28.

9. Hall, R. J. Cocaine in general surgery.

In: Cocaine and its use in ophthalmic and general surgery, by Hermann Jakob Knapp, M. D., New York & London, G. P. Putnam's Sons, 1885, pages 76-77.

10. Dawbarn, R. H. M. Water as a local anaesthetic. Its discovery American and not German. Med. Rec., N. Y., 1891, xl, 613.

(Refers to Halsted's discoveries in local and regional anaesthesia.)

11. Matas, R. Local and regional anaesthesia with cocaine and other analgesic drugs. The latest methods. Report of the chairman of the Section of Surgery of the Louisiana State Medical Society. Proc. Louisiana State Med. Soc., New Orleans, 1900, April 19-21. The growing importance and value of local and regional anaesthesia in minor and major surgery. Trans. Louisiana State Med. Soc., 21st Annual Session, New Orleans, 1900, page 329.

(In this contribution the several discoveries of Dr. Halsted in the domain of local and regional anaesthesia are duly credited and special reference to his precedence over all other investigators in establishing and demonstrating the principle of nerve blocking, is fully stated (see pp. 9, 10.)

12. Matas, R. Local and regional anaesthesia with cocaine and other analgesic drugs, including the subarachnoid method, as applied in general surgical practice. (Illustrated.) Phila. M. J., 1900, vi, 820-843. (See page 822.)

(In this paper full credit is given to Halsted and Hall for the first demonstration of neural cocainization "nerve blocking.")

13. Braun, H. Die Lokalanästhesie, Leipzig, 1905, page 77; page 405, bibliography, reference to Hall's paper on Dr. Halsted's injection of the inferior dental nerve.

14. Braun, H. Die lokal Anästhesie, Leipzig, 1907, i, 8, pp. 425.

(A recognized German authority in local and regional anaesthesia credits Halsted with the first clinical application of nerve blocking in dental practice. (7th chapter, p. 77; and again in the 9th chapter, p. 178; and again in the 11th chapter, p. 294.) While giving Halsted full credit throughout as the first discoverer and demonstrator of the principle of nerve blocking, he erroneously quotes the year of the discovery as 1885, whereas Dr. Halsted's experiments began in the fall of 1884, shortly after Koller's account, as shown in Hall's letter to the New York Medical Journal, December 6, 1884.)

15. Allen, C. W. Local anaesthesia, by Carroll W. Allen, with an introduction by Rudolph Matas, Phila. & London, W. B. Saunders Company, 1914, 625 p. including 255 ill. (See pages 3, 5, 150-152.)

Also: Local anaesthesia, 2nd. edition, 1918. (See pages 158-160.)

(Gives credit to Dr. Halsted for his several discoveries quoting from Dr. Matas *in extenso;* giving priority to Halsted in nerve blocking and other discoveries on local anaesthesia (see pp. 150-152).)

16. Bartlett, W. An estimate of the value of local anaesthesia in the surgery of today. Tr. South. Surg. & Gynec. Ass., Phila., 1920, xxxiii, 2-3.

17. Matas, R., and Kells, C. E. The discovery of conduction anaesthesia . . . . abstracted from the correspondence of Drs. Kells and Matas and from the reports of Dr. Matas to the Louisiana State Medical Society and the Philadelphia Medical Journal, November 3rd., 1900, entitled "Local and regional anaesthesia with cocaine, etc."

In: A booklet entitled "Dinner to Dr. Halsted, given by the Maryland State Dental Association, on the occasion of the presentation of a gold medal by the National Dental Association, at the Belvedere Hotel, Baltimore, April 1, 1922, to commemorate his pioneer work in the field of local surgical anaesthesia." Norman T. A. Munder & Co., Baltimore, 1922.

LOCAL ANAESTHESIA WITH WEAK SOLUTIONS OF COCAINE[1]

In reference to the cocaine solution, I agree with Dr. Matas that the principles which Schleich has emphasized, and which I emphasized before him, are very important ones. I wish to say a word in reference to the use of weak solutions. For many years we used solutions that had little cocaine in them. We began with a very weak solution and continued with water, while in some cases we used water alone. We found that very mild solutions of cocaine were better than water, and discovered that a 1 : 3000 or 1 : 5000 worked satisfactorily in every case. For ordinary purposes this is sufficient, and patients do better when very little cocaine is used. Their power of resistance is greater, and later they lose their inhibition, which is one reason for using mild solutions. I recall the case of an old gentleman from out of town who was suffering from two hernias where cocaine was used in the operation. A 1 : 1000 solution was employed for the first operation and he was much affected by the cocaine, although very little was used. For the first twenty-four hours he was much depressed, and said that he would not have the other side done. We finally persuaded him to let us do it, which we did with a very mild solution indeed. He had no bad effects and stood the operation much better.

My first publication on water as an anaesthetic is of course remembered, and in the two articles I wrote later all the points made by Schleich are discussed.

[1] Brief remarks in discussion of Dr. Rudolph Matas' paper, "Traumatic arteriovenous aneurisms of the subclavian vessels, with an analytical study of fifteen reported cases, including one operated by Dr. Matas.
American Surgical Association, Baltimore, May 7-9, 1901.
Tr. Am. Surg. Ass., Phila., 1901, xix, 293-294.

SURGERY OF THE INTESTINES

A CASE OF INTESTINAL INCARCERATION[1]

Dr. Wm. S. Halsted presented a specimen with the following history:

Anna B., aet. 35, Irish, widow, well nourished, and mother of eight children (youngest five years old), was admitted to Charity Hospital (Blackwell's Island), December 16, 1882, complaining of constipation, colicky pains, distension of the abdomen, and vomiting. The patient stated that, since her infancy, she had been subject to similar, but less severe attacks, and remembered five previous ones distinctly—the last having occurred in March of this year. Heretofore she had been promptly relieved by "medicine," her symptoms having persisted on only one occasion for as long a time as two days, and their subsidence being always coincident with the escape of much flatus. Constipation had attracted the patient's attention for several days prior to the present seizure, which developed suddenly, about one week before admission, while drinking a cup of tea. Since then nothing had passed from her bowels. She vomited on the 15th, for the first time, a little mucus, and had continued to eject, at intervals of several hours, frothy mucus and possibly bile, but at no time stercoraceous matter. The house physician gave a cathartic soon after admission. My attention was called to the case on the following day, December 17th. The recorded history being incomplete, I will recite it as accurately as possible from memory: I found the patient tossing from side to side, moaning loudly, and apparently in great distress. The countenance was slightly flushed but not anxious. The respirations were 27; pulse 98; temperature 98.5°. The thighs were flexed. The abdomen was much distended and unevenly so, everywhere tympanitic, and in no one region especially sensitive to pressure.

Diagnosis.—Intestinal obstruction.

I ordered morphine, hypodermically, and directed that enemata, as large as possible, should be administered with the longest available tubes.

December 18th.—The patient, confident that she was convalescing, assured us that she was free from pain and had passed "wind" per anum. Respirations were 22; pulse 104; temperature 98.5°. I could not ascertain positively how much urine had been voided, but the nurse estimated four ounces in twelve hours. The house physician stated that a hard oesophageal tube was introduced (per rectum) last evening to its fullest extent (about

[1] Presented at the New York Surgical Society, December 26, 1882. (Stenographic report has been reedited by the editor.) Although this article appeared previously to "Refusion in the treatment of carbonic oxide poisoning" (which is Dr. Halsted's first published contribution to surgery), it is not placed chronologically first in the volumes because it was not prepared by Dr. Halsted and is only a stenographic account of Dr. Halsted's report of a case at the New York Surgical Society. (Editor.)

N. York M. J., 1883, xxxvii, 241.

Also: Med. News, Phila., 1883, xlii, 113-115.

twenty inches), and that only one quart of fluid could be injected, which, when evacuated, brought with it mucus, but no gas and not a trace of faeces. I repeated the injection myself, with like result, and noticed that the tube was in several places most singularly bent and twisted.

19th.—5 p. m. Pulse 120, and intermittent. At 6 p. m. the patient was anaesthetized. Assisted by Dr. Weir, I proceeded to operate under the carbolic acid spray (1-40). The incision in the median line extended from the umbilicus to the pubes. Upon opening the peritonaeum a small quantity of serous fluid escaped through the wound. The large intestine, very much distended and presenting a few small superficial ecchymoses, occupied the entire field of view, being folded upon itself longitudinally. The separation of the folds exposed the quite normal small intestine. After a somewhat prolonged and unsatisfactory search for the cause of the obstruction, which was evidently below the flexura lienalis, there could be felt with the right hand a dense cylindrical band, about the size of one's little finger, very deeply situated, and stretching from near the promontory of the sacrum, obliquely upward and outward, to the parietes of the left hypochondrium, not far from the tip of the twelfth rib. The abdominal incision was then extended to within about two inches of the xiphoid cartilage. The obstructing cord being exposed, it could be seen to have its apparent origin from the transverse colon, and was divided between two stout catgut ligatures, which were passed around it by means of an aneurism needle. Below the band, and clearly compressed by it, were two tubes of large intestine, one of which filled with air as soon as released, while the other did not. The patient's condition was too bad to justify much further investigation, although it was evident that the disposition of the sigmoid flexure was most puzzling, and possibly offered another obstacle to the escape of intestinal contents. The distended colon, which had been protected throughout the operation by towels warmed in a solution of carbolic acid (1-40), was replaced without very much difficulty, and the wound united by a double row of sutures; the deep of silver, including the peritonaeum.

20th.—7 p. m. The patient died. Ever since the operation the patient was observed by the internes and nurses to have passed large quantities of gas from the bowels.

21st.—12 m. *Autopsy.*—There was quite firm union all along the line of the incision. The transverse colon was slightly adherent to the wound a little below the umbilicus. The large intestine reached to the fourth intercostal space on the left side. Attached to the anterior surface of the transverse colon at about its middle, and having its origin in the great omentum, was one portion of the divided band with its catgut ligature; the other part being intimately blended, and apparently continuous with the diaphragmatic peritonaeum between the eleventh and twelfth ribs. The specimens before you show the attachments of the band.

Figs. 14 and 15, drawn in the light of the autopsy, are intended to illustrate what presumably existed before, and immediately after, the operation. The *xxx* designate the sigmoid flexure looped and twisted upon itself from right to left. The sigmoideo-rectal junction was sufficiently narrowed in the bite of the volvulus to prevent the ready escape of flatus per rectum. This

constriction was evidently of very long standing, and intensified somewhat by the underlying falciform fold of its mesocolon which normally extends from the mesentery to the upper end of the rectum, and which, in this case, was unusually strong and prominent, with its concavity directed ventrally.

The *pathogenesis* may then have been: First, a noninflammatory adhesion in intra- or early extrauterine life of a considerable portion of large omentum (mesogastrium) to the parietal peritonaeum—adhesions of this nature being incidental to development, as urged by Langer and verified by Toldt; second, an embarrassed growth of the sigmoid flexure, giving

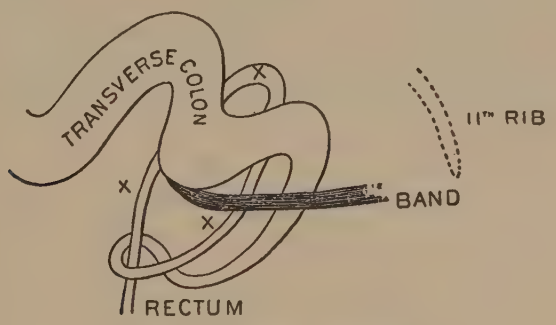

Fig. 14.—Before Operation.

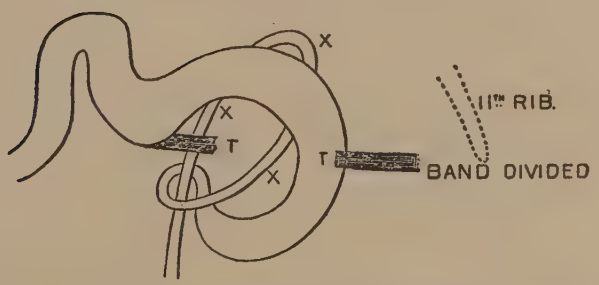

Fig. 15.—Immediately After Operation.

rise to a rotation of the same, which was permitted by the great length of the free mesocolon at that early period, or by its coincident development; third, a narrowed sigmoideo-rectal junction, its growth having been somewhat restrained and its lumen reduced by pressure from without; fourth, acute symptoms due, as suggested by Busch, to sudden distension of the gut above and the retraction of mucous membrane from below the omental band, possibly preceded by further intrusion of descending colon under the site of the constriction. I would suggest, in similar cases, the advisability of operating early, not only that the patient may survive the shock, but to anticipate a degree of hyperdistension of the intestine from which it can

never recover. If there is reason to suspect the existence of a further source of obstruction, or if the tension within the distended gut cannot be decidedly relieved by simpler measures, I believe that laparocolostomy or enterostomy, as the condition may dictate, to be indicated.

Following the discussion of this case by Drs. Sands, Weir, and Gerster, Dr. Halsted remarked that he also introduced a fine hypodermic needle into the distended intestines in his case, and observed precisely the same thing which Dr. Gerster had mentioned, namely, the exit of a small drop of intestinal fluid upon the withdrawal of the needle. Only a small amount of gas escaped, and that very slowly. Furthermore, Dr. Weir retained the intestines in position to a considerable extent by means of towels which had been dipped in warm, carbolized water, and after some manipulation they were returned to the abdominal cavity.

CIRCULAR SUTURE OF THE INTESTINE[1]

AN EXPERIMENTAL STUDY

Among the most brilliant triumphs of modern surgery are those which have attended operations involving laparotomy. We can offer a scientific explanation why many abdominal operations—above all, ovariotomy—should succeed so well even without the use of antiseptics. The chief danger of these operations is the development of peritonitis of a septic or purulent nature. Contrary to former beliefs Wegner[2] demonstrated experimentally that the mere exposure of the peritonaeum to the air does not cause peritonitis. The recent experiments of Grawitz[3] have shown that the access of the microorganisms of suppuration to the peritonaeal cavity does not alone suffice to induce peritonitis. The absorbing power of the peritonaeal surfaces is very great and, under favorable circumstances, pyogenic substances are quickly absorbed from the peritonaeal cavity without causing suppurative inflammation. In confirmation of the experiments of Grawitz I have inserted pure cultures of the pus organisms, as well as small pieces of suppurating tissue and particles of faeces, into the peritonaeal cavities of dogs without producing peritonitis.

Accessory causes must be present in order that pyogenic substances may induce purulent peritonitis. These accessory conditions, various as they may be, have in common the attribute that they prevent absorption or removal from the peritonaeal cavity of pyogenic substances, more particularly of the bacteria of suppuration.

Without entering into a detailed consideration of these conditions, the following may be mentioned as of especial importance in surgical operations involving the peritonaeum: the presence in the peritonaeal cavity of blood or other stagnating fluids, the existence of necrotic, wounded, or diseased tissue in connection with the peritonaeal cavity, and the presence of some focus from which pyogenic bacteria may enter the peritonaeal cavity in larger number or more rapidly than they can be absorbed. It is evident

[1] My experiments were completed April 1, 1887, and in a lecture which I delivered at the Harvard Medical School, April 5, 1887, I gave in substance what I have written for this article.

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[2] Wegner. Arch. f. klin. Chirurgie, Bd. xx.

[3] Grawitz: Charité-Annalen, Jahrg. xi.

that bacteria, which otherwise would be readily absorbed, may take lodgement and grow, if they find in the peritonaeum stagnating nutritive fluids or ulcerated and necrotic tissue. For manifest reasons dead spaces, which play such an important rôle in suppurative inflammations elsewhere, are less likely to be formed in the peritonaeal cavity than in most other situations.

The experimental results which have been mentioned and the deductions from them enable us to explain the brilliant success of skilful ovariotomists, even when, like Lawson Tait, they ostentatiously discard the use of antiseptics.

In striking contrast to the results of ovariotomy are those of intestinal suture. Not but that here, too, brilliant successes have been recorded, but the death-rate attending enterorrhaphy has been large, and, in general, the operation, even in the hands of the most skilful surgeons, has been capricious in its results. While admitting that an operation so delicate and so difficult in its technique as enterorrhaphy should be judged not by statistics collected at random from all possible sources, but by the results of individual operators of approved knowledge and skill, it yet remains true that even from this point of view the results are not satisfactory, although they are such as to encourage further efforts in perfecting the operation.

In the hope that an experimental investigation of the subject of intestinal suture might contribute somewhat to our knowledge of the causes of failure as well as of the conditions of success of enterorrhaphy, I have undertaken during the past winter a series of experiments in the Pathological Laboratory of The Johns Hopkins University, in Baltimore. I wish on this occasion to express my thanks to Prof. Wm. H. Welch, the Director of the Laboratory, for his kindness and advice, and also to acknowledge my indebtedness to Dr. F. P. Mall, Fellow in Pathology of The Johns Hopkins University, for his kind assistance in the operations, and especially for calling my attention to many points concerning the minute anatomy of the intestine. Dr. Mall's suggestions were of great value to me.

The experiments were performed upon dogs, anaesthetized usually with morphine and ether; they include sixty-nine circular resections and circular sutures of the small intestine.

The history of the operation of intestinal suture has been described so often and so well that it is not necessary in an experimental study of the subject to go over this historical ground again.

Before describing my experiments, I wish to call attention to certain points relating to the anatomy of the intestinal wall, a knowledge of which is of the utmost importance to the surgeon who performs intestinal suture. In looking through the literature of intestinal suture I cannot find that any one has called sufficient attention, from a surgical point of view, to the

structure of the different coats of the intestine, particularly to their physical properties. Indeed, the descriptions in surgical textbooks, as well as in monographs and articles treating especially of intestinal suture, and the drawings which are frequently inserted to elucidate the subject, lead me to believe that the current ideas among surgeons are not only incomplete, but absolutely incorrect as regards some important details in the structure of the intestinal coats. If these errors related to matters of only histological interest their practical bearing would be very slight, but my experiments have led me to attach great weight, in the successful performance of enterorrhaphy, to an accurate knowledge of the thickness and physical characters of the submucous coat of the intestine, and I am not aware that the importance of this coat in connection with this operation has hitherto been emphasized.

The old views of Jobert and Lembert as to the structure of the intestinal wall seem to have been adopted by modern surgeons with little or no modification. The peritonaeal coat, for instance, is believed to be thick enough and sufficiently strong to hold a stitch, and the existence of the submucosa, for us the most important coat, has been generally ignored.

A few quotations from recent writers will substantiate these statements. Thus Madelung,[4] in his admirable contribution to intestinal suture, writes, "The needle now penetrates in the usual manner the two ends of the intestine, passing between serosa and muscularis." Reichel[5] insists upon the accurate "adaptation of the two edges of the wound, particularly of the serous coats," and, having described the manner of taking the first row of stitches, continues, "over this comes then the external suture which includes only the serosa." Maydl,[6] Kocher,[7] and many others could be quoted in the same sense to show the prevalence of the idea that intestinal surfaces may be sutured by stitches including only the serous membrane.

I fail, moreover, to find in the writings of Gussenbauer, von Winiwarter, Kocher, Czerny, Rydygier, Madelung, Reichel, Maydl, and others the proper importance attached to the inclusion of a portion of the submucosa in suturing the intestine. The following quotations will suffice to show how little importance, from a surgical point of view, has been attached to the submucosa.

Reichel[8] completely ignores the existence of the submucosa when he says, "It is to be recommended in making the internal row of sutures, after

[4] Madelung: Arch. f. klin. Chirurgie, Bd. xxvii. p. 321.

[5] Reichel: Deutsche Zeitschrift f. Chirurgie, Bd. xix. pp. 268 and 270.

[6] Maydl: Allg. Wien. med. Zeitung, October, 1885, p. 475.

[7] Kocher: Centralblatt f. Chirurgie, 1880, No. 29, p. 466.

[8] Reichel: *Loc. cit.*, pp. 269 and 270.

carefully turning in the mucous membrane, to stick the needle close in front of the edge of the wound through the serosa and muscularis, and to draw it out at the edge of the wound between the muscularis and mucosa, and on the other border to proceed in reverse order."

Maydl,[9] too, recognizes but three coats, for he writes, "Then the two external, possibly retracted, intestinal coats are to be drawn together by means of several stitches which grasp the entire thickness of the intestinal wall with the exception of the already coaptated mucous coats, whereby serous surfaces when present are brought into broad apposition." Had Kocher appreciated the resistance furnished to the needle on entering the submucosa, he might have explained how perforation into the lumen of the gut is to be avoided, and not merely have said, "The wall of the intestine is

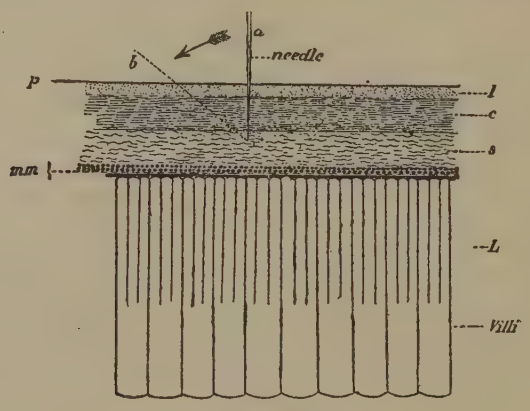


Fig. 16.

p. Peritonaeum. *l*. Longitudinal Muscular Coat. *c*. Circular Muscular Coat. *s*. Submucosa. *mm*. Muscularis Mucosae. *L*. Glands of Lieberkühn.

not to be punctured in its entire thickness,"[10] and "we passed the stitches according to Lembert through the thickness of the intestinal wall, avoiding, if possible, penetrating the lumen."[11] Czerny, who has for a long time devoted himself earnestly and most usefully to the subject of intestinal suture, does not refer to the submucosa in describing the technique of the operation.[12]

Fig. 16, kindly drawn for me by Dr. Mall, is a diagram of the wall of the dog's intestine, and is intended to represent accurately the relative thickness of the several coats. The serosa is prolonged beyond the outer muscular coat to emphasize its thinness. Between the submucosa and glands

[9] Maydl: *Loc. cit.*, p. 489.

[10] Kocher: Correspondenzblatt f. Schweizer Aertze, 1878, p. 155.

[11] Kocher: Centralblatt f. Chirurgie, July, 1880, p. 468.

[12] Czerny: Berlin. klin. Wochenschrift, November, 1880, p. 641 *et seq.*

of Lieberkühn—in other words, between it and the lumen of the intestine—practically nothing intervenes; and, literally, nothing but the two layers of muscularis mucosae and fibrosa mucosae respectively. Fully two-thirds of the thickness of the wall of the intestine is mucous membrane. When the needle, therefore, has been passed through its outer third it must have entered the glands of Lieberkühn and, hence, the lumen of the gut. It is an easy matter to isolate the submucosa. The outer muscular coats strip from it readily, and the mucous membrane can be rapidly scraped off with a knife. Thus obtained, the submucosa is found to be an exceedingly tough, fibrous membrane. It is air-tight and water-tight, and is the "skin" in which sausage meat is stuffed. It is, moreover, the coat of the intestine from which "catgut" is made.

A needle, on being pushed vertically through the wall of the intestine, meets with considerable resistance when it reaches the submucosa; and still greater resistance is encountered if it be attempted to pass the needle horizontally through its meshes. A delicate thread of this tissue is very much stronger and better able to hold a stitch than is a coarse shred of the entire thickness of the muscular and serous coats. Upon the discovery of the latter fact, at which I was, perhaps, as much surprised as most surgeons will be at the statement of it, it naturally occurred to me that it would, if feasible, be well to include a portion of the submucosa in the suture. Before attempting this, however, I wished to test the merits of a suture which included nothing but the serosa and muscularis, and I, therefore, performed the following experiment:

Experiment A.—Small young dog. Operated on January 18, 1887. Irrigation with solution of corrosive sublimate, 1: 1000. Needles with *dulled ends* employed for sewing. Circular resection of intestine. Two rows of interrupted stitches passed as deep as, but not including any portion of, submucosa—suture of muscular coat. The stitches tore out badly (particularly those of the first row) and had to be frequently retaken.

January 23d.—Dog found dead. *Autopsy:* Suppurative peritonitis; sutures had given way completely.

Blunt needles were used in the foregoing experiment to enable me to penetrate down to, and no deeper than, the submucous coat. Dr. Mall had previously called my attention to the fact that, with the eye-end of a needle, one would not unwittingly puncture the submucosa; for the force required to enter it at all with the rounded end of a needle is sufficient to perforate it, and, that too, not without a positively unmistakable and characteristic jerk. I soon discovered that, even to the sharpened end of a needle, sufficient resistance is offered by the submucosa to be easily appreciable, and that it is possible and, with very little practice, not difficult to pick up at each stitch

a thread-like piece of submucosa without incurring the danger of passing into the lumen of the gut.

Persuaded by Experiment A, and others of a similar nature, that the musculo-peritonaeal suture is not to be trusted, I performed Experiments B and C in order to test the advisability of taking up, with each stitch, a thread of the submucosa.

Experiment B.—Medium-sized dog. Operation January 18, 1887. To include in each stitch a thread of submucosa. Irrigation with solution of corrosive sublimate, 1:10,000. Glass clamps; suture, catgut. Two rows of interrupted stitches.

January 25th.—Dog has been doing very well ever since the operation.

February 19th.—Apparently perfectly well. Killed. *Autopsy:* Circular intestinal wound perfectly healed; no adhesions, except slight ones over the line of suture anteriorly.

I wish to call attention here to a point to be emphasized more prominently later, viz., that whereas in Experiments 1 and 2 of Group I, the adhesions were, as we shall see, extensive enough to have eventually caused death in one case, and to have threatened it in the other, in Experiment B they were strikingly trivial.

Experiment C.—Operation January 20, 1887. To reverse about one foot of intestine. (This operation was done for a purpose not belonging to the subject of this article.) Steps of operation: 1. Complete section of intestine in two places, about one foot apart. 2. Afferent (proximal) ends stitched together. 3. Efferent (distal) ends brought together over the line of suture of afferent ends, and sutured. Straight needles. Two rows of interrupted silk stitches. With each stitch a thread of submucosa was taken up. Irrigation with solution of corrosive sublimate, 1:10,000.

Dog died of shock a few hours after operation. *Autopsy,* by Dr. Mall: Careful examination of suture made, to ascertain if any of the stitches had penetrated into the lumen of the gut; not one was found to have done so. No peritonitis.

This experiment was a satisfactory one to me, in that it demonstrated the feasibility of carrying the stitches into the submucosa.

To satisfy my curiosity, I made experiments D, E, and F.

Experiment D.—Small, brindled and white bulldog (pup). Operation January 29, 1887. To suture the submucosa alone. 1. Split muscularis for about two centimetres from cut edges along mesenteric and free borders of intestine. 2. Stripped back the muscular flaps thus marked out and exposed two centimetres of submucosa. 3. Applied two rows of interrupted stitches to the exposed submucosa, appropriating but a thread of it to each stitch. 4. Sewed the musculo-peritonaeal flaps together over the line of the circular suture.

January 31st.—Dog found dead. *Autopsy:* Complete slough of flaps, and gaping of circular wound.

Experiment E.—Large, long-haired, white dog. Operation January 21st. Circular suture of submucosa alone. 1. Circular division of musculo-peritonaeal coat, and stripping off of cuffs to expose about one centimetre of submucosa. 2. Buried-knot quilt (*vide* Fig. 17) stitches applied before completing the section of the gut. 3. Section of gut completed, and buried-knot quilt stitches tied. 4. Two rows of continuous submucosa suture. 5. Cut edges of musculo-peritonaeal cuffs turned out, and the under surface of the cuffs coaptated, and held by a few stitches.

February 1st.—Dog is dead. *Autopsy:* Submucous stitches still hold; but gangrene, starting from the musculo-peritonaeal cuffs, extends for about one foot above the circular suture.

Experiment F.—Operation same as in Experiment E. Dog died of ether.

We are now prepared to consider my first series of operations. In order to classify conveniently the modes of suture, the experiments will not be numbered precisely in the order in which they were performed.

Group I. Lembert's Stitches

Experiment 1.—Small, young, black bitch. Operation January 6, 1887. Resection of about two and a half inches of small intestine. Glass-slide clamps. Irrigation with solution of corrosive sublimate, 1: 40,000. Suture, fine sublimate silk. Two rows of interrupted stitches.

January 7th.—Dog walks about. Is not much depressed. Vomits occasionally. Has been seen to pass, per rectum, a few drops of blood-stained mucus.

8th.—Dog is playful. No evidence of peritonitis. Takes milk.

11th.—Apparently perfectly well.

February 7th.—Dog emaciated almost to a skeleton. Has refused food for about one week. Is evidently dying of starvation. Killed. *Autopsy:* Line of suture adherent to adjacent intestines. Several acute bends in intestine, two or three inches apart, caused by adhesions. Intestine nowhere dilated. Mucous membrane at the line of suture quite flat.

Riedel [13] relates a similar case, the death of a dog from inanition, due to finger-like bending of the intestine, without dilatation or other evidences of obstruction.

Experiment 2.—Medium-sized, gray dog. Operation January 19th. No antiseptics. Irrigation with warm physiological salt solution. No clamps. Suture, two rows of Lembert's stitches. Fear that too much tissue has been turned in.

January 25th.—Dog has not been very lively since the operation, but takes milk naturally.

27th.—Dog appears better.

February 1st.—Seems perfectly well.

2d.—Killed. *Autopsy:* Omentum adherent over line of suture; numerous other adhesions. Intestine, above suture, dilated to about four times its natural size. Suture perfectly firm.

[13] Riedel: Deutsche Gesellschaft für Chirurgie, 1883, p. 25.

Experiments 3, 4, 5.—Operations December 12, 13, and 14, 1886. To isolate loops of intestine. Double circular resection, and double suture. Suture, horse-hair.

All three cases died within two or three days of the operation, from purulent peritonitis.

Experiment 6.—Young, small, brindled dog. Operation January 9, 1887. To isolate loop of intestine. 1. Intestine divided in two places, about one foot apart. 2. Ends of gut thus isolated, sewed together. 3. The remaining ends stitched together to establish the intestinal continuity. Irrigation with solution of corrosive sublimate, 1:4000. Glass clamps. Suture, fine sublimate silk. Czerny's "Etagennaht." Operation lasted two hours. As the abdominal wall was being sewed, fresh ether was administered, and the dog died of respiratory paralysis. The heart continued to beat for more than fifteen minutes after the respiration had ceased. No attempt was made to revive the animal by artificial respiration.

Experiment 7.—Small, brindled bitch. Operation January 10, 1887. To isolate loop. Steps of operation the same as in Experiment 6. Czerny's suture. Twenty minutes required for the loop suture, and fifteen minutes for the continuity suture. One hour and fifteen minutes for the entire operation. Dog ceased breathing as abdomen was being sewed. Heart continued to beat. Artificial respiration employed for thirty minutes before active respiration became reestablished.

January 11th.—Dog still alive, and able to walk. No vomiting. Natural stool.

12th.—Found dead. *Autopsy:* Local peritonitis referable to sutures. Each stitch occupies a focus of pus. Conclude that the silk used may not have been sufficiently disinfected, for it was not placed in the sublimate solution until just before the operation was undertaken.

Experiment 8.—Rather large, black and white dog. Operation January 8, 1887. To isolate loop of intestine. Irrigation with solution of corrosive sublimate, 1:10,000. Glass clamps. Suture, catgut; Hagedorn's needles. Three rows of Lembert's stitches. Many of the stitches tore out, and had to be reapplied. Some, certainly, perforated into lumen of gut. Expressed myself at the time as being dissatisfied with the operation. Felt sure that the dog would die, because I thought that I had been unusually clumsy in my technique.

January 9th.—Dog lively, and seems well.

25th.—Dog has not had a bad symptom since the operation.

February 1st.—Not so well.

3d.—Refuses both meat and drink.

9th.—Dog is evidently starving to death. Reopen abdomen, find many and very strong adhesions. Both circular sutures firm. The isolated loop is distended to about the size of an inflated human transverse colon, with faecal-smelling, thick, brownish-gray fluid; and its wall is two or three times as thick as normal.

That these cases (Group I) testify to the defectiveness of my technique, I am eager to admit; at the same time I find no proof that the method of any one else has been otherwise than very uncertain. The single-resection experiments (Group I), although they might be called successful, must, when contrasted with Experiment A, and with those which are to follow (Group II), be regarded with dissatisfaction. The serious adhesions which were present in the former cases, indicate an imperfect method; and in the absence of any such in the latter lies the promise of a better technique. The most favorable accounts of single resections on dogs come from Madelung and Rydygier. The one reports nine, and the other ten experiments as successful.

Studying Rydygier's cases,[14] I observe that, whenever an autopsy was made, extensive adhesions were found, as is evident by the following quotations:

"EXPERIMENT 1. . . . . The site of resection is bound by adhesions to the contiguous loops of intestine."

"EXPERIMENT 2. . . . . The intestinal loops which lie near to the site of resection, are bound together by adhesions."

"EXPERIMENT 3. . . . . The site of resection, which is completely healed, is bound by adhesions to the abdominal wound; furthermore, several loops of intestine are glued together.

"EXPERIMENT 4. . . . . The abdominal wound is healed, and the omentum is adherent to it. Several loops of intestine are matted together about the site of the resection, and in separating them the intestinal suture gives way to a slight extent."

Furthermore, of the six unautopsied animals, not one, perhaps, had lived long enough, at the time of Rydygier's writing, to justify the belief that death from adhesions might not ultimately have ensued.

Rydygier's tenth experiment was made September 7th, and on the 10th of October of the same year his article appeared.

We cannot analyze Madelung's work on dogs, because he has not thought it worth while to detail his experiments. In recommendation of his "Knorpelplattennaht," he says:[15]

"I wish to say in its favor, that in the nine experiments on animals in which I performed in this manner circular intestinal and gastric resection, an immediate and complete union took place in every instance. In no instance did escape of faeces take place. I do not think it worth while to give a detailed account of these experiments, which were instructive enough to me."

[14] Rydygier: Berlin. klin. Wochenschr., 1881, p. 593.

[15] Madelung, *l. c.*, p. 323.

I have no doubt that the results of the gentlemen just quoted were much better than I could have obtained by their methods as they describe them; for each, with his great experience, must have acquired an *art* of sewing which, from a *scientific* standpoint, is not sufficiently precise to be communicated to others.

To read Kaiser's [16] experiments is to become convinced of the uncertainty with which, in the taking of stitches, he must contend who does not avail himself of the guidance offered by the submucosa.

"Experiment 1. . . . . Autopsy reveals a silk thread projecting into the lumen of the intestine, about which there is a small lens-like depression."

"Experiment 3. . . . . On the stomach, on its inner side, one recognizes the cicatrix in the slightly elevated ridge. On the duodenum, very close to the cicatrix, are two silk ligatures which lead into two small pouches."

The fact that both of these experiments succeeded notwithstanding that, in each, stitches had been passed into the lumen of the intestine or of the stomach, makes it more than probable that Kaiser is not the only one who, in spite of an imperfect technique, has had good results.

The experiments of mine to which I particularly wish to invite attention are those of Group II. In all of the operations of this group the plain-quilt submucosa stitches were employed for the complete row; and in most of them a few presection buried-knot (*vide* Fig. 17 and Group III) quilt stitches were taken in addition.

Group II. Plain-Quilt Submucosa Stitches

Experiment 1.—Large, black-and-tan dog. Operation January 25, 1887. Double circular suture: to reverse about one foot of intestine.[17] Irrigation with solution of corrosive sublimate, 1: 10,000. Glass-slide clamps. Suture. Seven presection stitches in incomplete first row; and ten plain-quilt (post-section) stitches in second row. Intestine well washed with warm water just before being replaced.

January 26th.—Dog wags his tail, but otherwise rather quiet.

February 1st.—Very lively, and seems perfectly well.

8th.—Dog continues to be well.

27th (about five weeks after the operation).—Has been losing appetite and spirits for a week or more. Killed. *Autopsy:* Both circular sutures perfectly healed—adhesions not nearly so extensive as in Experiment 8 (Group I), the successful "Étagennaht" loop case. The further description of the autopsy is reserved for another purpose.

[16] Kaiser: Beiträge zur Operativen Chirurgie (Czerny), 1878, p. 142.

[17] *Vide* Experiment C.

EXPERIMENT 2.—Large, black Newfoundland bitch. Operation February 28th. Double circular suture: to reverse one foot of intestine. Very free irrigation with solution of corrosive sublimate of uncertain strength—probably 1:1000. Suture, sublimate silk. Five presection stitches—one complete row of plain-quilt postsection stitches.

March 2d.—Dog found dead. *Autopsy,* by Dr. Mall: Absolutely no peritonitis and no adhesions. Lines of suture perfectly firm. Unmistakable evidences of too much irrigation, and with a too strong solution of corrosive sublimate. Ulcers of mucous membrane of stomach. Subperitonaeal haemorrhages—particularly over bladder, etc.

EXPERIMENT 3.—Very large, black Newfoundland dog. Operation March 4, 1887. Double circular suture: to reverse one foot of intestine. Irrigation with solution of corrosive sublimate, 1:20,000. Considerable contamination of sutures and intestines with faeces throughout the operation.

March 6th.—Dog so savage that no one can enter the room in which he is confined.

April 1st.—Dog has not had a bad symptom since the operation.

May 7th.—Killed. *Autopsy* made by Dr. Welch, who writes me that the dog "was very weak and emaciated, and could not have lived much longer. We found the same condition of things as in the other case.[18] There was a mass of solid material, made up mostly of bits of straw, wood, and hair, which formed a firm impaction, beginning above and extending an equal distance below the upper suture, but not reaching down more than halfway between the two sutures. The intestine was much distended at the seat of the impaction and also, although to a less extent, above the impaction. There were very few adhesions. The peritonaeum was clean, and the intestine beautifully healed at the site of the sutures—the inner surface being perfectly smooth."

EXPERIMENT 4.—Moderately large, yellow dog. Operation February 19, 1887. Single circular resection and circular suture. Irrigation with solution of corrosive sublimate, 1:20,000. Suture, sublimate silk. Six presection buried-knot quilt stitches, and one complete row of postsection plain-quilt stitches.

February 20th.—Dog moderately lively.

March 11th.—Perfectly well. Killed to make injection of liver. *Autopsy:* Suture perfectly healed. A very few slight adhesions.

EXPERIMENT 5.—Large, white dog. Operation March 5, 1887. Single circular resection and circular suture. 1. Application of seven presection buried-knot quilt sutures. 2. Ligation of vessels by circumvection ("Umstechung"). 3. Application of clamps. 4. Section of intestine very close to presection stitches. 5. Tying of presection stitches. 6. Application of plain-quilt stitches (rather *too far* from cut edge of intestine). 7. Tying of plain-quilt stitches.

March 11th.—Dog seems perfectly well. Killed to make injection of vessels of circular suture. *Autopsy:* Slight local peritonitis starting from a small necrotic ulcer (ulcer has not perforated gut wall—is rather super-

[18] Experiment 1, Group II.

ficial) very near the mesenteric border, at line of circular suture. This ulcer proceeded undoubtedly from strangulation where the stitches (both rows) were closest together.

EXPERIMENT 6.—Large, yellow dog. Operation March 8, 1887. Single circular resection and circular suture. Intestine cut very close to presection stitches. Postsection plain-quilt sutures applied nearer than usual to the presection stitches.

March 25th.—Dog has had no bad symptoms since the operation. Killed. *Autopsy:* No adhesions, except a very delicate attachment of omentum to line of suture, anteriorly.

EXPERIMENT 7.—Small, shaggy, yellow dog. Operation March 8, 1887. Single circular resection and circular suture. A few presection stitches; one complete row of postsection plain-quilt stitches.

March 14th.—Dog has made an uninterrupted recovery. Used for a second experiment for another purpose. Killed. *Autopsy:* No adhesions. Circular suture beautifully healed, but so much intestinal wall had been turned in that some obstruction had been caused—manifested by conical dilatation of intestine, and accumulation in it of hay, on the proximal side of the suture.

This case is one of several which indicate that it is not advisable to make two rows of stitches on small dogs.

EXPERIMENT 8.—Very large, brown dog. Operation March 14, 1887. Single circular resection and circular suture. A few presection and one complete row of postsection sutures. Operation performed without an assistant, and without the employment of antiseptics. No clamps. Irrigation with a solution of common salt, 0.6 per cent., at 37° Cent.

March 25th.—Dog has made an uninterrupted recovery. Killed. *Autopsy:* No adhesions—not even of omentum to the line of the suture. A very perfect result.

This operation was performed without any antiseptic precautions, and without an assistant; and yet, as the autopsy showed, the result could not have been more perfect.

EXPERIMENT 9.—Rather large, black and white dog. Operation March 18, 1887. Single circular resection and circular suture. A few presection and one complete row of postsection stitches. Even less attention paid to cleanliness than in the preceding experiment: for the dog was operated upon to furnish situations from which to make drawings. About one foot of intestine was exposed outside of the abdominal cavity for more than two hours; and when returned was very blue and much swollen. But the sewing was very carefully and satisfactorily done.

April 1st.—Dog is very lively, and seems well. Used by Dr. Mall for another operation. Killed. *Autopsy:* Intestinal wound firmly healed, but the intestines, at the site of the suture, are matted together.

It is not strange that the intestines should, in this case, have been matted together; but rather to be wondered at that, under the circumstances, the

dog could have made even such a recovery, indifferent as it appears from our present point of view.

EXPERIMENT 10.—Large, black dog. Operation March 17, 1887. Single circular resection and circular suture. Operation without antiseptics and without clamps. Suture. A few presection and one complete row of post-section stitches. The silk was so very old that it broke often on tying, and many of the stitches had to be retaken. I am quite sure that one—possibly two—of the stitches were passed into the lumen of the gut. More than one foot of intestine allowed to remain outside of the abdominal cavity for one and three-quarter hours. The dog had tapeworm and much faeces in his intestine, so that there was a good opportunity for contamination of the wound and of the abdominal cavity. Very free irrigation, during and after the completion of the circular suture, with a warm salt solution—0.6 per cent. Should this case recover, I shall regard it as very strong evidence in favor of my suture.

April 2d.—Dog lively, and apparently well. Dr. Mall killed the dog, subsequently, and appended the following to the history: *Autopsy:* "No peritonitis. Suture fully healed. A large worm (*Eustrongylus gigas*), alive and active, found in the peritonaeal cavity."

EXPERIMENT 11.—Rather large, white bitch. Operation February 1, 1887. Single circular resection and circular suture. One complete row of plain-quilt submucosa stitches (*vide* Fig. 22) applied before and tied after resecting about half an inch of intestine. I found the taking of these stitches very easy, but to resect the gut under them was somewhat troublesome. The method, on the whole, is a moderately rapid one—occupying about forty minutes.

February 2d.—Dog doing nicely.

26th.—Dog perfectly well. Killed. *Autopsy:* No adhesions. A most perfect result.

It will be observed that in this (the foregoing) case, as well as in all of the following cases of this group, the incomplete row of presection stitches was omitted; and that but one row of stitches was employed for the circular suture.

EXPERIMENT 12.—Very large, olive-brown dog. Operation February 1, 1887. Resection of two feet of intestine. I made, at first, a circular suture of Emmert's stitches (*vide* Fig. 23); then, being dissatisfied with the appearance of the suture, I again resected the intestine and applied one complete row of plain-quilt stitches.

February 2d.—Dog convalescent.

3d.—Dog lively, and apparently well.

March 9th.—Still perfectly well. Killed. *Autopsy:* No peritonitis, and absolutely no adhesions.

The intestinal wound had healed so perfectly that its site was only discovered after Dr. Mall and I, in search of the suture line, had run the intestine several times through our fingers.

Experiment 13.—Small, shaggy, black dog. Operation February 14, 1887. Circular resection and circular suture. One complete row (eighteen stitches) of plain-quilt stitches. Irrigation with tepid salt (0.6 per cent) solution, and, sparingly, while tying stitches, with a solution of corrosive sublimate—1 : 20,000.

February 15th.—Dog is quiet—still affected by morphine.

16th.—Dog is very playful.

March 10th.—Perfectly well. Killed. *Autopsy:* Circular suture perfectly healed. Slight adhesion of the omentum to the line of the suture.

Experiment 14.—Very small, old, black and tan bitch. Operation February 21, 1887. Circular resection and circular suture. One row of plain-quilt presection sutures (*vide* Fig. 22). Intestine very small; the smallest, I think, that I have ever sutured.

March 7th.—Dog has been doing fairly well ever since the operation, but has refused food for a day or two.

March 9th.—Found dead. *Autopsy:* No peritonitis. Near the site of the circular suture the gut is found to be much twisted, and bound in this position by adhesions, in themselves very trivial. Above the twist the intestine is very much dilated. Death from ileus. The suture is most beautifully healed, even to mucous membrane inclusive.

Experiment 15.—Large, brown and white bitch. Operation March 3, 1887. Circular resection and circular suture. One complete row of plain-quilt, postsection stitches. Glass clamps. Irrigation with 1 : 12,000 corrosive sublimate solution.

March 14th.—Dog has made an uninterrupted recovery. Given to the janitor for a pet.

June 1st.—Dog perfectly well.

Although there were but fifteen experiments in this group, they include eighteen circular sutures of the intestine, all of which were successful. In three instances, about one foot of intestine was reversed, and a double circular suture required. Furthermore, the making of two circular sutures at one time, particularly when accompanied with reversal of a portion of the intestine, increases more than twofold the danger to the animal operated upon.

But what chiefly distinguishes these results, is the *absence of adhesions.* In five of the experiments (2, 7, 8, 11, and 12) there were absolutely no adhesions; nor were there any such in Experiments 6 and 13, save the slight ones between the omentum and the face of the line of the suture. In only one instance were the intestines matted together as described by Rydygier and other surgeons, and as seen by me in so many of my earlier experiments. They who have attempted double circular resection and double circular suture can best appreciate the magnitude of the operation of reversing a portion of the intestine, and can understand, perhaps, my great faith in the suture which has given such results. Experiments 8, 9, and 10 were per-

formed without clamps, without antiseptics—except for the silk, which had been prepared in the usual way—and without especial attention to cleanliness, save that the intestinal wound was diligently washed with a warm salt solution while the stitches were being tied. It may be asked why adhesions should be so strongly objected to. Not so much to the adhesions as such is it objected—although we have seen and already called attention to the fatal consequences of the obstruction which may attend them—as to the imperfect technique which constantly admits of the matting together of the intestines.

Adhesions of this nature imply inflammation; and an inflammation of an extent which, though it may not usually prove disastrous, is always more or less dangerous. The less extensive the inflammation, the greater the certainty that the suture will hold. It cannot, fairly, be urged that time may have swept away the adhesions in my cases, for the autopsies, at which no adhesions at all were found, were made two (Experiment 2), six (Experiment 7), eleven (Experiment 8), twenty-five (Experiment 11), and thirty-six (Experiment 12) days after the operations.

It is believed that the method of operation adopted in the experiments of Group II combats more satisfactorily than any hitherto suggested the dangers which naturally attend suture of the intestine. The great danger to be apprehended is, as already mentioned, the development of suppurative peritonitis as the result of the operation.

Let us consider for a moment the various factors which during or after the operation of intestinal suture may lead directly or indirectly to the production of purulent peritonitis. In judging of the efficacy of the factors we are guided by the results of the experiments mentioned in the beginning of this article.

In the first place, whence may the pyogenic substances come which are essential to the production of suppurative peritonitis? Evidently either from outside of the body through the wound in the abdominal wall or from the intestine through the wound in its coats. There is, of course, no especial danger of infection of the peritonaeal cavity from the exterior in the performance of enterorrhaphy, as compared with other operations requiring laparotomy. This is not a danger, therefore, which needs any especial consideration in this connection or which is to be regarded as serious.

The chief danger of infection of the peritonaeal cavity is manifestly from the contents of the intestine, in case they find their way through the wound in the intestine or along the lines of suture. There is a possibility of the escape of intestinal contents at the time of the operation, but this is a danger which can be readily guarded against and one which is much less likely to be attended by serious results than the escape of intestinal contents into the peritonaeum subsequent to the operation. Probably too much impor-

tance has been attached to the use of antiseptic solutions for irrigation in intestinal resection (*vide* Experiments 8, 9, 10, and 13).

Although in performing enterorrhaphy on the human being I should be unwilling to discard what seems undoubtedly to be an additional precaution, I should, in the light of my experiments, and of several of my operations, hesitate to employ solutions as strong as those commonly advised.

We are brought, therefore, to the conclusion that the chief danger of infection of the peritonaeum is from the passage of the intestinal contents (bacteria) into the peritonaeal cavity *subsequent* to the operation. The conditions which may lead to this unfortunate occurrence are (1) failure to close completely and firmly the wound of the intestine; (2) penetration of the intestinal lumen by one or more sutures; (3) giving way of the sutures; (4) ulceration or sloughing of the intestine at the site of suture.

In order to bring about complete and firm closure of the abnormal opening into the intestine it has been customary to make several series of sutures of the intestine one over the other in the form of the so-called "Etagennaht." In this way a considerable extent of the intestinal wall is folded in, the circulation of which is greatly impeded. There are especial dangers which attend the folding in of an unnecessarily large amount of intestinal wall, for, on the one hand, this increases the extent of tissue which undergoes sloughing and thus increases the danger of infection, and, on the other hand, the flange formed by the folds projecting into the intestinal lumen is an obstacle to the passage downward of the faeces, which, accumulating at and above the site of suture, increase the tension upon the sutures and endanger their separation.

Experiments will subsequently be described which show that these dangers are not imaginary, but real. A sufficiently firm closure of the wound in the intestine with much less danger from the sources mentioned is accomplished by the method adopted in the experiments of Group II, and which will be described subsequently.

Although experiments have already been cited which show the possibility of recovery even when stitches in the final row of sutures have penetrated the lumen of the intestine, nevertheless, it is plain that this penetration of the intestinal lumen is an accident which may lead to serious consequences, and it is to be carefully avoided. While it has been the aim of previous operators to avoid this accident, no definite rules have been laid down by which this is to be accomplished. I wish, therefore, in this connection to lay especial emphasis upon the importance of appreciating, as can be done in the manner already described, the moment when the point of the needle comes into contact with the submucous coat of the intestine. By observing

this, it is within our power so to guide the needle that, while including a bit of submucous tissue, it does not penetrate the mucous coat.

Of no less importance in guarding against the third danger of peritonaeal infection from intestinal contents, is care that each stitch in the final row shall include a bit of submucous tissue. Utterly misleading is the usual direction, that the stitches shall include only serous membrane, or even serous membrane and muscular coat. Experiment A was given precedence in the list of the experiments described in this article, in order to give prominence to the fallacious character of this direction. Any one, by a simple experiment, can convince himself how frail is the hold of sutures which include only serosa and muscularis. I am inclined to regard perforation of the gut-wall, on the one hand, and the tearing out of stitches, on the other, as the leading factors in the production of the peritonitis which has brought about the fatal issue in many cases of intestinal suture.

The occurrence of ulceration or necrosis of the intestinal wall at the seat of suture, is a danger which is twofold in its action. It renders possible the escape of intestinal contents, and it affords a soil suitable for the lodgement and growth of bacteria. How important is the latter factor has been made apparent by the experiments of Grawitz previously cited. Especial dangers attend necrosis of the serous and subjacent coats of the intestine, even when the necrosis does not extend to the mucous membrane; for, doubtless, intestinal bacteria, which otherwise would prove harmless, may reach the diseased tissue and find suitable conditions for their development.

We must not forget that the predisposition to infectious inflammation is necessarily always present in circular suture of the intestine, and lies in the interference with the circulation which the suture causes, but it should be our aim to reduce this predisposition to a minimum. The circular suture disturbs the circulation both directly and indirectly: directly, in so far as the stitches produce constriction of the tissues which they include; and indirectly, in that it bends a portion of the intestinal wall at right angles to its original long axis. To these causes of disturbance of the circulation is to be added the pressure from above of the contents of the intestine upon the flange which is projected into the lumen in the form of the involuted intestinal wall. I am inclined to believe that this projecting flange acts, perhaps, less as a cause of intestinal obstruction than as a factor predisposing to the formation of adhesions, which, to the best of my knowledge, have seldom been absent in the obstruction cases. It has seemed to me that these adhesions have been particularly luxuriant when too much tissue has been turned in by the circular suture.

The results which were obtained in the series of experiments constituting Group II, furnish a sufficient answer to the plea that it is desirable to turn

in over a large extent the edges of the intestinal wound, in order to bring as much of the peritonaeal surfaces as possible into contact. As has been shown, a sufficiently extensive adaptation of peritonaeal surfaces to each other can be accomplished without inverting an excessive amount of intestine, and thus with less impairment of the vitality of the intestine, and consequently less predisposition to peritonitis.

If the turning in of tissue predisposes to too extensive inflammation, perhaps the greatest danger of turning in too much is not that the flap may play the part of a stricture, but that the circulation at the site of the suture may be so much interfered with that union will not take place.

Experiments G and H were made partly to determine if this were so, and partly to assist in establishing my belief that one could not, with safety, invert as much tissue in small as in large dogs.

Experiment G.—Very small, brown bitch. Operation March 5, 1887. To employ two rows of quilt stitches in suturing the intestine of a very small animal.

March 9th.—Died. *Autopsy:* Gangrene of inverted edges. No union.

Experiment H.—Very small, black-and-tan terrier bitch. Operation March 7, 1887. To employ two rows of quilt stitches in suturing the intestine of a very small animal. Intestine so small that, after the second row of stitches was tied, the gut at the site of the suture looked quite white, especially along the convex border.

March 11th.—Dog not well. Killed. *Autopsy:* Gangrene of flap, as expected. Purulent peritonitis.

If two rows of stitches are so dangerous in very small dogs, why use presection stitches even in large dogs?

This question leads us to the consideration of the technique.

Technique.—When the gut has been completely divided there ensues, immediately, a spasm of the circular muscle fibres nearest the cut edges, which inverts the mucous membrane, and almost closes the newly made intestinal orifices. The spasm of these fibres lasts but a few seconds: it is succeeded by a relaxation of the same, and by a contraction of the adjacent circular fibres; and now the mucous membrane is rolled out. It is exceedingly troublesome to take the stitches properly when the mucous membrane is thus everted. To relieve myself of this annoyance, I devised and tested various presection stitches, and, finally, adopted the one represented in Fig. 17.

To distinguish it from the other forms of quilt stitch, I have called it the buried-knot quilt stitch.

The four threads, two from each side, are tied at one time, and the knot becomes buried in the folds which have been raised up thereby. From five to

seven presection stitches—ten to fourteen half-stitches—are taken; two of these are at the mesenteric border, one on each side, and just at the attachment of the mesentery. The needle is introduced on a line with one of the radii (*vide* Fig. 16, *a*) of a transverse section of the intestine, and pressed upon gently by the pulp of one finger until the resistance offered by the submucosa is encountered; it is then tilted (*vide* Fig. 16, *b*) through ninety degrees, or until about parallel with the long axis of the gut, pressed on with a little more force than before, tilted still further, and, finally, passed out. It is reintroduced almost, but not precisely, where it emerged (*vide* Fig. 17), passed through in the same manner as before, but in the opposite direction, and its thread divided. The threads of the half-stitches from both sides, when straightened out, naturally cross each other, and lie upon the portion of intestine to be resected. There is an opportunity for the exercise of some

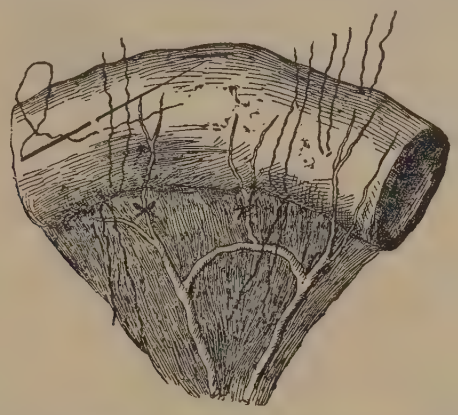


Fig. 17.—Presection, Buried-Knot Quilt Half-Stitches.

discretion in the selection of a spot on the mesenteric border for the introduction of the first stitch. The vessels distributed to the intestine are ensheathed in more or less fat, usually in enough to make the mesenteric border obscure except at certain places between vessels which are rather far apart. These places are often entirely free from fat and, if the mesentery be not pulled upon, are concave.

At the bottom of any one of these little concavities (*vide* Fig. 18) the needle can be introduced with greater precision than it could be at a point where fat obscures the mesenteric border. The first presection stitch (half-stitch), so taken, can be seen through the mesentery, and serves as a guide for the taking of the corresponding stitch (half-stitch) on the other side.

I sew with what are called milliner's needles. These needles differ from the ordinary cambric needles, only in that they are disproportionately long, and, hence, easier to handle. Nos. 9 and 10 are good sizes for the purpose.

Finer sizes cannot be threaded easily. Black silk is preferable to white because it contrasts more strongly with the parts to be sewed. The silk was prepared by soaking it—on the spool—in a solution of corrosive sublimate, 1 : 1000.

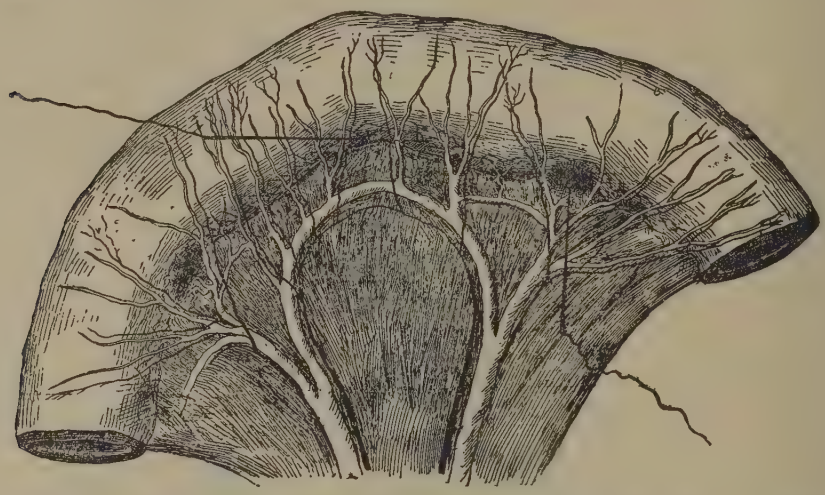


Fig. 18.—Introduction of Needle Into Concavity, Free From Fat, in Taking the First Presection Stitch.

When all the presection stitches have been introduced, the vessels of the part to be resected are ligated (*vide* Fig. 17, ×) by circumvection with one of the threaded milliner's needles. Then the intestine is divided as close as possible to the presection stitches (*vide* Fig. 19). It is better to make a circular division of the wall of the intestine than to cut through both walls at once. By cutting rather rapidly one can take advantage of the first mus-

Fig. 19.—Intestine Divided Close to Presection, Buried-Knot Half-Stitches.

cular contraction, and can complete this part of the operation before eversion of the mucous membrane has taken place. The presection stitches being tied, the eversion of the mucous membrane is prevented and the way prepared for the application of the complete row of what may be called *plain*-quilt stitches (*vide* Fig. 20).

The plain-quilt stitches include, like the presection stitches, threads of the submucosa, and should be placed a little nearer to the cut edges than

Figs. 20 and 21 would lead us to suppose. They should all be applied before a single one is tied. It is impossible to preserve a straight line of application if each stitch be tied as it is taken—the tendency being to depart, in an outward direction, more and more from the straight line. The distance from each other at which the stitches should be taken cannot be given at once for all of them—so much depends upon the spasm of the circular muscle fibres along the line of, and caused by the taking of the stitches. The contraction does not, as a rule, supervene until several stitches have been taken; but,

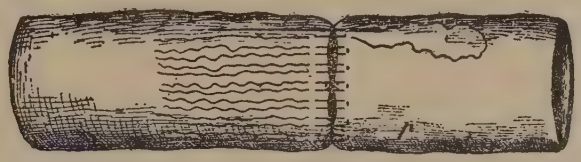


FIG. 20.—Presection, Buried-Knot Stitches Tied; Plain-Quilt, Postsection Stitches Introduced.

once set up, it extends in a circle in advance of the stitches, and must be taken into consideration in the application of them. Before the last stitches have been applied the muscular tissue concerned is, frequently, no longer able to respond to the stimulus of stitch-taking, and the intestine assumes its natural size. During the period of muscular contraction the stitches must be applied very close to one another—perhaps one to one and one-half millimetres apart—but before and after this contraction an interval of two to

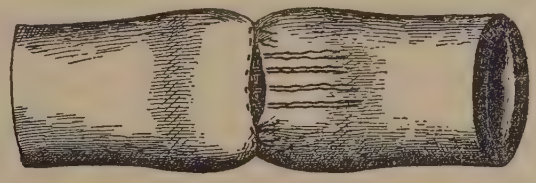


FIG. 21.—Intestine After All but Four of the Plain-Quilt Stitches Have Been Tied.

two and one-half millimetres may be left between them. The wall of the gut rolls in of itself as the stitches are tied (*vide* Fig. 21), and the entire operation can be conveniently performed without an assistant. The threads must not be drawn so tightly in tying as to make the tissue included in the stitch look very anaemic.

In five of my operations (Experiments 11, 12, 13, 14, 15, Group II) the incomplete row of presection stitches was not employed; and, although the results justify the belief that it may with safety be omitted, the operation is so greatly facilitated by its use that I should be sorry, without good reason, to discard it.

In no instance was a triangular piece of mesentery exsected; nor did I ever sew together the edges of the rent which was always made in the mesentery, for fear of including vessels which might contribute to the blood supply of the sutured parts.

Irrigation.—The fluid used for irrigation, if neither too strong nor too hot, seemed to have little or no influence upon the results. A solution of corrosive sublimate—1: 20,000—was the one commonly employed, and I should prefer a weaker (1: 30,000 to 1: 40,000) solution to a stronger.

We had the opportunity, repeatedly, to observe the immediate bad effects on the intestine of solutions hotter than 38° Centigrade; and ultimately I became partial to cold or slightly tepid solutions for irrigation, because, with the use of them, the wall of the intestine did not become so much swollen, and the stitches could, therefore, be applied with greater precision.

I was always especially careful to have the wound freely irrigated during the tying of each knot, and thus precluded the possibility of imprisoning foreign matter between the opposed peritonaeal surfaces.

Clamps.—The intestine was usually clamped with glass microscopical slides of the English pattern; first made to embrace the gut, they were then tied together about their middle by a disinfected string; lastly, a short piece of rubber-tubing was introduced, on the stretch, between the converging ends of the slides; and, by slipping the tubing toward or away from the string, the pressure exercised by the clamp could be diminished or increased. Aside from its simplicity and the readiness with which it can be applied, the clamp has, in addition, this in its favor, that through its glass blades the state of the circulation in the intestinal wall may be watched.

Abdominal Wound.—The incision was always, save once, made in the linea alba, and as near to the pubes as practicable. If it was carried too far in the direction of the xiphoid cartilage, we were annoyed by the protrusion of a fatty flap covered by peritonaeum, which seemed to spring from the posterior surface of the lower piece of the sternum and from the upper part of the inner surface of the anterior abdominal wall.

Before cutting through the peritonaeum we covered the dog with two large disinfected towels (a procedure suggested by Dr. Mall), and stitched them to the edges of the abdominal wound and, above and below it, to each other.

The abdominal wound was closed usually with two rows of sutures. The first row, made with interrupted stitches of silkworm gut, included everything but the skin. The cut edges of skin were then brought loosely together by a continuous suture taken from its under surface and from the underlying loose connective tissue. The wounds were dressed with horsehair taken from a corrosive sublimate solution, 1: 1000, and were bandaged with crinoline.

Preparation and Care of the Dogs.—Only one of the dogs operated upon (Exp. 3, Group II) was dieted before the operation, or isolated after it. The dogs were frequently fed on the day of the operation, and were always allowed to run about, all together in a large room, as soon after it as they might be inclined. Milk was given to them as soon as they would take it, but solid food was withheld for about one week.

Anaesthetics.—Morphine, hypodermatically (3i-3iv of a 5 per cent solution), followed by a few inhalations of ether.

Neither Neuber's intestinal tubes nor any other similar contrivances were made use of to simplify the performance of circular suture of the intestine; because, (1) they were not believed to be necessary; and (2) it was thought that they would increase the danger of the operation.

The employment of an incomplete row of buried-knot presection stitches facilitates the application of the subsequent complete row quite as much as does the use of the Neuber's tube. Furthermore, when a Neuber's tube is used, an incomplete row of postsection stitches must be taken; and, as we have repeatedly said, the application of first row *postsection* stitches is troublesome, whereas it is easy to apply presection stitches.

I believe that when the circular suture is made over a tube of any kind the circulation in the immediate neighborhood of and along the line of suture is additionally obstructed. And should the tube slip to the slightest extent out of place, or soften too quickly, the circular intestinal wound may leak; for I have repeatedly observed that a suture which answered the purpose over a tube failed to close the wound sufficiently when the tube was removed.

The Preparation and Preservation of the Needles.—Madelung and other surgeons have called attention to the fact that, in order to save time at the operation, it is well to have the needles threaded beforehand, and hence, to have a method of protecting the disinfected, threaded needles permanently from rusting. Madelung suggests keeping them in alcohol. I have tried, among other fluids, glycerine and alcohol, and found both of them too hygroscopic for the purpose. The difficulties seem to be most readily met by the adoption of an antiseptic oil. I have used with satisfaction the oil of juniper berries. It is, furthermore, necessary to have a means of supporting the needles in the oil, and above the water with which the oil is, from the picking up of the needles with wet fingers or wet forceps, sooner or later, certain to become contaminated. It is not enough to place the needles on a wire-netting supported in the oil; for drops of water will surely be sustained at the points where the needles cross each other, and where they cross the wires, and at the points where the wires interlace.

Until we know of a better method of preserving the needles for immediate use, I would suggest the following one: Thread the needles with dry silk. Tie the silk with one knot in the eye of the needle. Bend to a little more than a half cylinder an oblong piece of very fine brass wire-netting on its long axis, and thrust the points of the threaded needles through the netting along the line of its greatest convexity. When a needle has been passed almost through the netting wind its thread about the half cylinder and tie the ends of the thread together near the eye of the needle. When all the needles have been introduced, and their threads wound and tied, place the wire-netting thus armed in a cylindrical jar filled with the oil of juniper berries. Use the lowest needles first.

It certainly would be a great gain to the technique if such presection *half*-stitches could be devised, that one complete row of them on each side of the

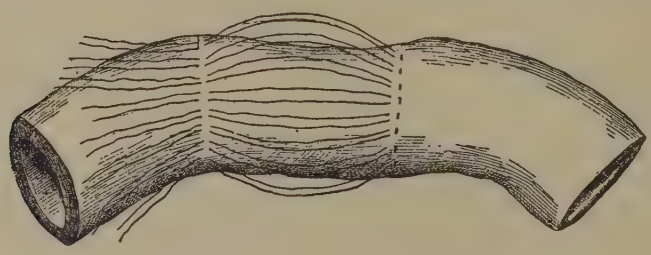


Fig. 22.—Plain-Quilt, Presection Stitches Introduced.

portion of intestine to be resected would suffice for the circular suture. I say *half*-stitches because, though the application of *complete* presection stitches (*vide* Fig. 22) is easy, it is rather annoying to resect under them and to arrange them for tying (*vide* Experiments 11, 14, and 15, Group II).

I have tried to perform circular suture of the intestine with presection *half*-stitches—one complete row of them on each side of the portion of intestine (*vide* Groups III and IV)—and, thus far, with unsatisfactory results.

Group III. One Complete Row of Buried-Knot, Presection Submucosa Sutures

(For buried-knot stitches, *vide* Fig. 17, p. 203, and Fig. 20, p. 205.)

Experiment 1.—Small, black dog. Operation February 2, 1887. To make single circular suture with one complete row of presection, buried-knot stitches. The operation lasted three-quarters of an hour from the first cut into the abdominal wall until the application of the dressing. Irrigation with solution of corrosive sublimate of uncertain strength.

February 3d.—Dog evidently not feeling well.

5th.—Found dead. *Autopsy:* No signs of inflammation in the peritonaeal cavity; not even at the site of the suture. Positive evidences of corrosive sublimate irritation (*vide* Experiment 2, Group II. Autopsy).

Experiment 2.—Small skye-terrier. Operation February 2, 1887. To make a single circular suture with one row of buried-knot, presection stitches. The operation for circular suture lasted thirty-five minutes. Irrigation with the same strong corrosive sublimate solution as in the preceding case.

February 3d.—Dog found dead. *Autopsy:* Subperitonaeal vascular injection and haemorrhagic extravasations. Blood-tinged fluid in the peritonaeal cavity, etc. The circular suture is firm; holds water injected with sufficient force to distend the intestine. Death from too strong an irrigation fluid.

Experiment 3.—Rather small skye-terrier. Operated February 3, 1887. Same suture as in foregoing cases. Operation performed in thirty-four minutes.

February 8th.—Dog is dying. *Autopsy:* Purulent peritonitis, starting from the circular suture.

Experiment 4.—Small fox-terrier. Operation February 4, 1887. Same suture as in foregoing experiments of this group. Irrigation with solution of corrosive sublimate, 1 : 10,000.

February 8th.—Dog is dying. Killed. *Autopsy:* Purulent peritonitis, starting from line of circular suture.

Experiment 5.—Medium-sized, fox-terrier bitch. Operation February 7, 1887. Same suture as in foregoing experiments of this group. Irrigation with ordinary cold water.

February 21st.—Dog is failing. Killed. *Autopsy:* Intestines badly matted together by adhesions. Circumscribed abscess cavity surrounding, almost completely, the circular suture, which later appeared to be firmly healed.

Experiment 6.—Medium-sized, jet-black bitch. Operation January 27, 1887. To reverse a portion of the intestine. Double circular suture. Presection buried-knot stitches. Operation lasted one and three-quarters hours.

January 29th.—Dog died. *Autopsy:* Purulent peritonitis.

Experiment 7.—Medium-sized dog. Operation February 4, 1887. To reverse portion of intestine. Operation the same as in Example 6.

February 9th.—A. m., suddenly taken sick. P. m., died. *Autopsy:* Peritonitis. Abdomen distended with sero-purulent fluid.

Group IV. Emmert's Stitches

In the experiments of this group such presection stitches were applied as are represented in Fig. 23.

The idea of making such stitches I believed to be original with me, until I ascertained that I had been anticipated in the conception of them by

Emmert,[19] who, however, had employed them only to sew up linear wounds of the intestine, and not for the circular suture.

Experiment 1.—Operation January 20, 1887. Single circular suture by one complete row of Emmert's stitches.

January 21st.—Dog, evidently, has peritonitis.

22d.—Found dead. *Autopsy:* Suture had given away. Suppurative peritonitis.

Experiment 2.—Large pointer dog. Operation February 9, 1887. The same suture as in Experiment 1.

February 11th.—Dog found dead. *Autopsy:* Purulent peritonitis starting from the circular suture.

Experiment 3.—Small black-and-tan dog. Operation February 11, 1887. Single circular suture (Emmert's stitches) as in Experiments 1 and 2.

February 12th.—Dog died. *Autopsy:* Purulent peritonitis starting from the circular suture.

Fig. 23.—Emmert's Stitches.

I shall not record the rest of my experiments on circular suture of the intestine, because most of them seem, now, rather absurd to me, and none of them admit of classification.

Summary

1. It is impossible to suture the serosa alone, as advised by authors.

2. It is impossible to suture unfailingly the serosa and muscularis alone, unless one is familiar with the resistance offered to the point of the needle by the coats of the intestine. Furthermore, stitches which include nothing but these two coats tear out easily, and are, therefore, not to be trusted.

3. Each stitch should include a bit of the submucosa. A thread of this coat is much stronger than a shred of the entire thickness of the serosa and muscularis. It is not difficult to familiarize one's self with the resistance furnished by the submucosa, and it is quite as easy to include a bit of this coat in each stitch as to suture the serosa and muscularis alone.

4. It is unnecessary in performing circular suture of the intestine to make more than one complete row of stitches if they be of the plain-quilt

[19] Emmert: Pitha and Billroth's Handb. d. Chirurgie, Absch. vii. p. 209.

variety. Unless all of the stitches of the row are applied before a single one is tied, it is impossible to preserve a straight line in the application of them.

5. It facilitates the operation very much to make five or six presection sutures; for the eversion of the mucous membrane, which otherwise takes place and makes the application of first-row, postsection stitches troublesome, is thus prevented. The first presection stitches should be introduced at the mesenteric border of the intestine, and at a place as free from fat as possible.

6. The plain-quilt stitches are to be preferred to the ordinary Lembert's stitches (Knopfnähte) because (1) one row of them (the former) is sufficient for the circular suture; (2) the knots of the first row of Lembert's stitches prevent the most accurate apposition of the opposed peritonaeal surfaces; (3) the plain-quilt stitches constrict the tissues less than the Lembert's stitches; and (4) the former tear out less easily than the latter. Madelung's cartilage-plates, which he employs partly to prevent the tearing out of the stitches, are unnecessary when a bit of the submucosa is taken up with each stitch.

7. The vessels of the excised intestine should be ligated by circumvection ("Umstechung"). It is not necessary to exsect a triangular piece of mesentery; and it is unadvisable to sew together the edges of the rent in the mesentery, for, in so doing, one might include small vessels which contribute to the blood-supply of the sutured parts.

8. Solutions of corrosive sublimate stronger than 1:20,000 should not be used for irrigation. It would be better, perhaps, to employ weaker solutions (1:30,000 or 1:40,000). The irrigation should be attended to most diligently when the stitches are being tied.

INTESTINAL ANASTOMOSIS[1]

We have killed today three of a series of dogs operated upon for the production of intestinal anastomosis. The results are so gratifying that it gives me pleasure to be able to show to you the first specimens. In two of the specimens there are no adhesions; in one there is a delicate adhesion at one spot between the omentum and the line of suture.

The success of any form of intestinal suture is inversely proportionate to the extent of the adhesions which result from the employment of the particular method. The method which we employ is a new one. The success of it depends, I believe, upon the appreciation of the importance of the submucous coat of the intestine. It is remarkable that no one has recognized the important part which this coat should play in operations for intestinal suture; it is still more remarkable that surgeons could have altogether overlooked the existence of the submucosa; and it is perhaps most remarkable that experimenters and writers on the subject of intestinal suture should without exception believe that it is possible to take a stitch of the peritonaeal coat alone. The crude views of Jobert and Lembert as to the construction of the wall of the intestine have been universally accepted by surgeons up to the present time. The peritonaeal coat is believed to be thick enough and sufficiently strong to hold a stitch and the existence of the submucous coat has been ignored.

About three years ago I endeavored to emphasize the importance of the submucous coat in operations upon the intestine[2] but only succeeded in attracting attention to the quilt or square stitch which I still employ in all sutures of the intestine.

The peritonaeum is so thin that one cannot represent it by the finest pencil stroke unless the wall of the intestine be magnified to a thickness of about 5 cm.; *vid* Fig. 16. It is absurd therefore to speak of a stitch of the serosa. A stitch which includes only the peritonaeal and muscular coats is a very weak and unreliable one. The submucosa is an exceedingly tough coat. A thread of it is sufficient to insure the safety of the stitch. Each stitch should include at least a thread or two of the submucosa. If the submucosa be perforated the intestinal lumen is almost certainly entered; *vid.* Fig. 16.

[1] Presented before The Johns Hopkins Hospital Medical Society, Baltimore, December 1, 1890.

Johns Hopkins Hosp. Bull., Balt., 1891, ii, 1-4. (Reprinted.)

[2] The American Journal of the Medical Sciences, October, 1887.

Sufficient resistance is offered to the point of a needle by the submucosa to enable one with a very little practice to recognize this coat as soon as it is encountered and to take up a small bit of it without entering the lumen of the intestine.

Allow me to demonstrate to you the submucosa and then the method by which one may with certainty catch up a small shred of the submucosa with-

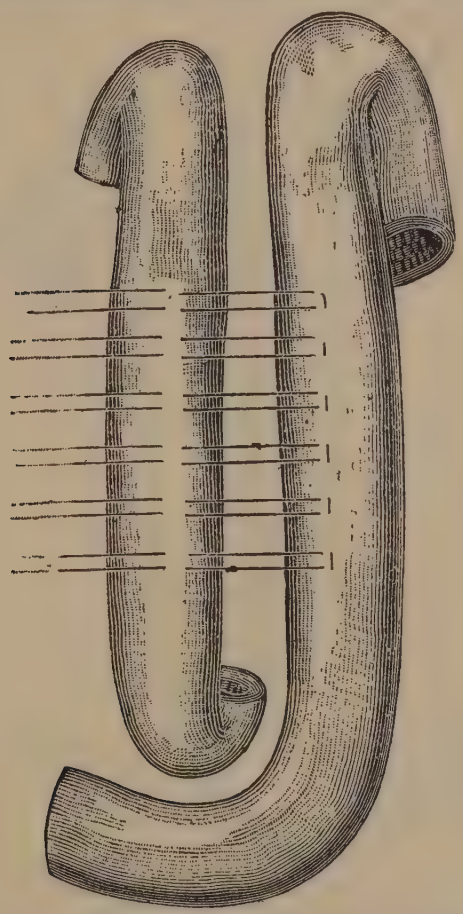


Fig. 24.—Posterior Row of Sutures Applied.

out perforating this coat of the intestine. To isolate the submucosa, engage the intestine firmly between the handles of a scissors and pull the intestine, thus. The handles allow nothing but the submucous coat to pass between them. The serous and muscular coats are being stripped off as you see from the outer side, and the mucous coat which you cannot see is being stripped off from the inner side of the submucosa. You will observe when I inflate the submucosa that it has not been torn by this rough manipulation. I now

catch up a fine shred of it with this threaded needle. Please test the strength of this shred by pulling the loop of thread which passes under it. If the cotton thread were not so heavy it is doubtful which would be broken, the cotton thread or the shred of the submucosa. The stitch which I am now taking includes the serous and both muscular coats but not the submucosa. You will observe that the thread tears through the muscle about as easily as it would through putty.

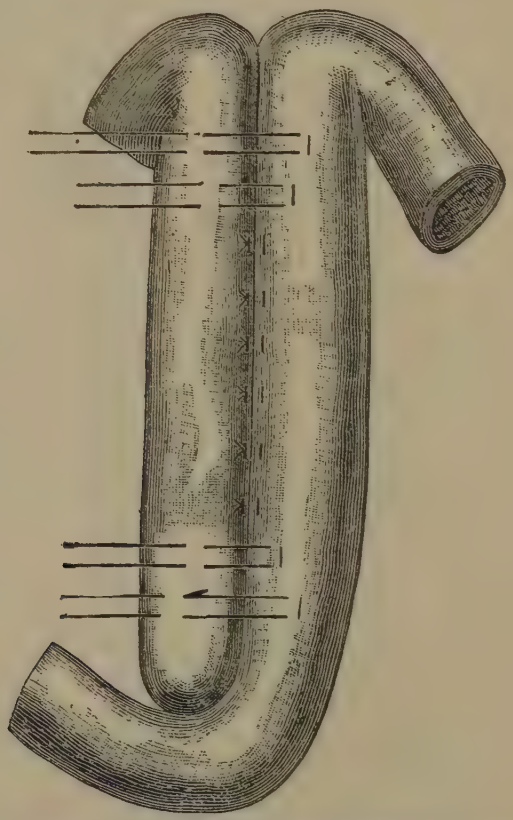


Fig. 25.—Posterior Row of Sutures Tied. Lateral Sutures Applied, but Not Tied.

With a fresh piece of intestine let me prove to you that one can with certainty pick up with each stitch a thread of the submucosa without entering the lumen of the intestine. This is a fine milliner's needle which I am using. The point of it has now passed through the muscular coats and I feel distinctly the resistance offered to it by the submucosa. The needle should be introduced by pressing on its blunt end with the pulp of one of the fingers. If the needle be grasped between the fingers the resistance offered to it by the submucosa is not so readily recognized. I am sure that I have picked up

a thread of the submucosa and that I have not entered the lumen of the intestine. To prove that I have not entered the lumen of the intestine let us split the gut and scrape away its mucous membrane and the two very delicate coats—the muscularis mucosae and the fibrosa mucosae—which lie between this and the submucosa. You will observe that the stitch has not perforated the submucosa. Now between the handles of the scissors we will draw the submucosa. It is stripped clean on both sides and the cotton thread

Fig. 26.—Posterior and Lateral Sutures Tied.

still clings to its surface by a delicate shred of this very tough tissue. For the performing of an intestinal suture of any kind I would emphasize the following statements:

1. It is bad surgery to employ a stitch which enters the lumen of the intestine.

2. It is impossible to suture the serosa alone.

3. It is impossible to suture unfailingly the serosa and muscularis alone unless one is familiar with the resistance offered to the needle by the coats

of the intestine. Furthermore, stitches which include nothing but these two coats tear out easily and are, therefore, not to be trusted.

4. Each stitch should include a bit of the submucosa. A thread of this coat is much stronger than a shred of the entire thickness of the serosa and muscularis. It is not difficult to familiarize one's self with the resistance

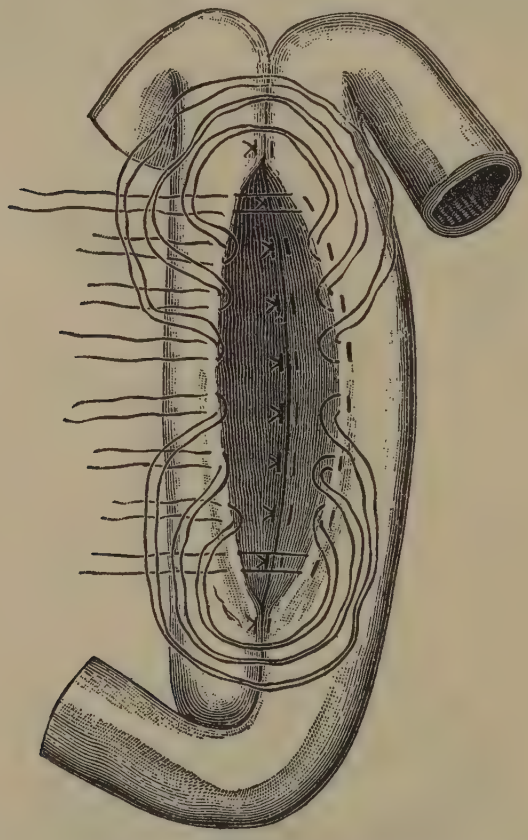


Fig. 27.—Anterior Row of Sutures Applied and Drawn Aside. Intestines Not Yet Incised.

furnished by the submucosa, and it is quite as easy to include a bit of this coat in each stitch as to suture the serosa and the muscularis alone.

5. As many as possible of the stitches should be taken and of these as many as convenient should be tied before the intestine is opened.

6. The quilt of square stitches are to be preferred to the Lembert's stitches because one row of them (the former) is sufficient, and because they tear out less easily and constrict the tissues less than do the Lembert's stitches. Madelung's cartilage plates for circular suture of the intestine are superflu-

ous when the square stitches are used and when a bit of the submucosa is taken up with each stitch.

The interest in intestinal anastomosis was revived by Senn a few years ago. A very serious objection to Senn's operation and to all of the many modifications of it is this; all of the sutures perforate the wall of the intestine.

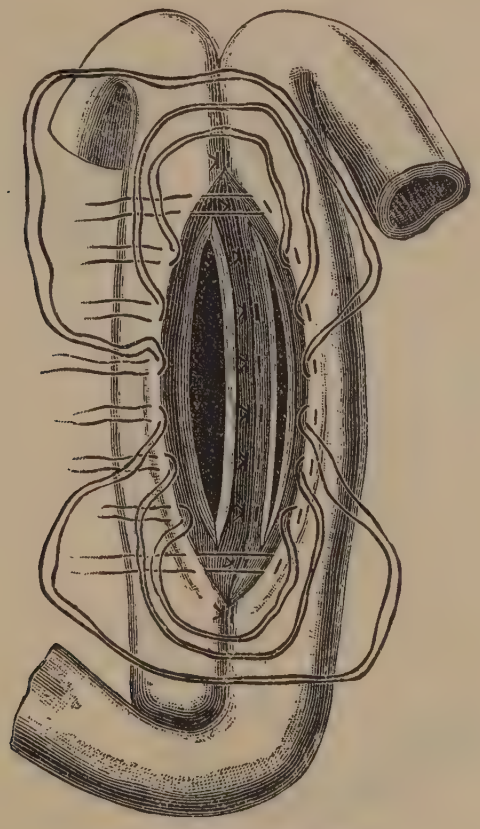


Fig. 28.—Intestines Incised.

In operating for intestinal anastomosis we proceed as follows: six square or quilt stitches are taken in a straight row near the mesenteric borders of the selected portions of the intestine and tied; *vid.* Figs. 24 and 25.

At each end of this posterior row of stitches and nearer the convex border of the intestine two lateral square stitches are applied (*vid.* Fig. 25) and tied; *vid.* Fig. 26.

A little beyond the convex border the eight or nine square stitches which constitute the anterior row and complete the oval are applied but not imme-

diately tied. They are first drawn aside (*vid.* Fig. 27) to make room for the knife or scissors with which the intestines are then opened; *vid.* Fig. 28.

Finally the sutures of the anterior row are tied (*vid.* Fig. 29) under a constant and gentle irrigation with a tepid salt solution, 6-1000, which is poured from the flask in which it was sterilized.

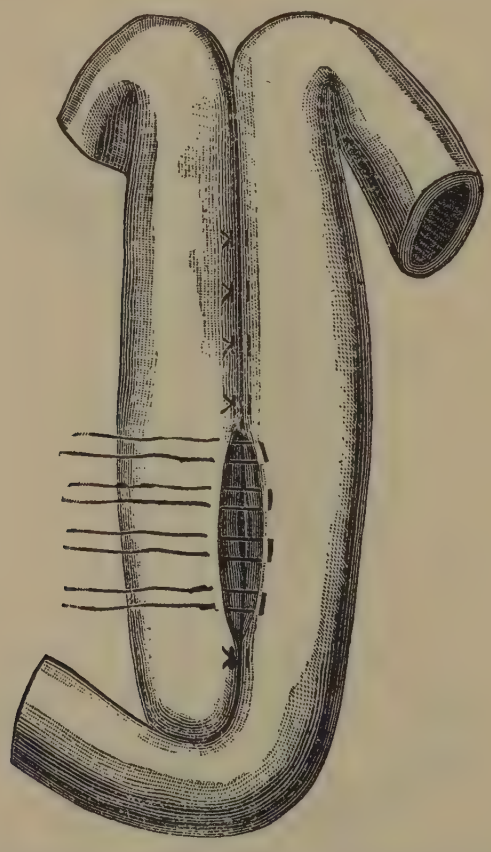


Fig. 29.—Anterior Row of Sutures—Four Tied and Four Not Tied.

Dr. Jas. Brown was kind enough to note the time which one of the operations required and reported it as 8½ minutes.

The dogs which were killed today were operated upon three, four and five weeks ago. Already all of the sutures have so far worked their way out of the intestinal walls that they are to be seen shimmering through the peritonaeum as little loops of black silk. Inasmuch as there are no adhesions every stitch can be seen distinctly. On cutting open the specimens we see that the anastomosis has been satisfactorily established in every case.

This operation for intestinal anastomosis has the following advantages:

1. None of the stitches perforate the intestinal wall.

2. All of the stitches are applied and more than half of them are tied before the intestines are opened.

3. The square stitches are employed.

The Preparation and Preservation of the Needles

I think that milliner's needles are the best for all intestinal sutures. These needles differ from the ordinary cambric needles only in that they are very long and hence easy to manipulate. Nos. 8 and 9 are good sizes for the purpose. Finer sizes cannot be threaded easily. Black silk is to be preferred to white because it contrasts more strongly with the parts to be sewed. In order to save time at the operation the needles should be threaded beforehand. Each thread should be about 25 cm. long and should be tied in the eye of its needle. A fresh needle and thread should be used for each stitch.

It is well to keep a large stock of threaded needles constantly on hand. To prevent the threads from becoming entangled we baste them parallel to each other in small fine towels—about 25 threaded needles in each towel. A towel thus armed is sterilized by steam just before the operation and is then spread out in a solution of carbolic acid, 1-40. Each threaded needle is withdrawn from the towel only as it is required.

RECURRENT VOLVULUS[1]

According to Braun of Königsberg (Langenbeck's Archives, 1892), detorsion has been accomplished in seventeen cases of volvulus of the sigmoid flexure. Six, or about 35 per cent, of these cases recovered. Of the 11 fatal cases, 2 died of collapse soon after the operation, 5 of peritonitis or gangrene of the intestine, 1 of pneumonia, 1 of a recurrence of the volvulus, 1 of typhoid fever, and 1 probably of tuberculous meningitis.

In two instances the volvulus recurred; in one, immediately after the operation, and in the other, four months after the operation. Both of these cases died; one without a second operation, and the other on the third day after the operation, presumably of typhoid fever.

Dr. Finney's case is, therefore, the second in which detorsion for recurrent volvulus of the sigmoid flexure has been accomplished, and the first in which it has been successfully accomplished.

Four patients, for whom detorsion was not performed because the volvulus was not discovered at the time of the operation, died soon after the operation. Resection of the intestine for volvulus of the sigmoid flexure has been done in two instances. One of the patients died on the thirty-second day from perforations of an ulcer of the stomach; the other recovered from the operation with, however, a faecal fistula.

All of the eight cases upon whom enterotomy was performed died within a very short time.

It is clear from these statistics that for volvulus of the sigmoid flexure detorsion should be performed as soon as possible. The proposition of Treves, to puncture the intestine and then perform colotomy on the descending colon, should, as Braun says, not for a moment be considered. To prevent a recurrence of the volvulus it has been proposed by Senn to shorten the mesocolon. Senn has accepted the popular notion that a long mesocolon is the predisposing cause of volvulus of the sigmoid flexure. This notion has not, however, the support of facts. In almost all of these cases a short, thick mesocolon has been found. Gruber has found the mesocolon as short as 1 inch and not longer than 2½ inches in the cases which he has examined post mortem. Küttner has seen both arms of the sigmoid flexure lying close together.

[1] Remarks in discussion of Dr. J. M. T. Finney's paper, "Recurrent volvulus." The Johns Hopkins Hospital Medical Society, Baltimore, January 16, 1893.

Johns Hopkins Hosp. Bull., Balt., 1893, iv, 28.

If one should attempt to shorten the mesocolon in such cases he would, as Braun says, produce a sharp bend of the intestine. He might, furthermore, shut off the circulation to a disastrous extent.

In our case the mesentery seemed quite as long if not longer than the normal mesosigmoideum. May it not after all be possible that a long mesentery is often the predisposing cause of the volvulus, and that an originally long mesentery may, by adhesions and other processes of peritonitis, become a short and thick one?

There is a physiological volvulus of the sigmoid flexure. A torsion of as much as 180° has several times been observed.

There is also a physiological volvulus of the large intestine upon the small intestine. The entire navel loop is concerned in this volvulus. It occurs in the embryo when the flexura linealis crosses the flexura duodeno-jejunalis. It is probably this twist which causes the fold known as the plica duodeno-jejunalis, and the fossa known as Treitz's fossa or the recessus duodeno-jejunalis or recessus retroperitonaealis. It is a subject for investigation whether the ligamentum mesenterio-mesocoelicum owes its occasional existence to a physiological volvulus of the sigmoid flexure.

A DIAGNOSTIC SIGN IN APPENDICITIS[1]

Male, aet. 30. I exhibit this case not for any particularly interesting feature of its own, but because I wish to call your attention to a diagnostic sign of appendicitis which I believe to be of considerable importance. My experience would teach me that this particular sign is probably present in all cases, and in all stages, except one, of the disease.[2] It is this: One cannot press with the fingers into the false pelvis on the affected side so deeply as on the healthy side. In the earliest stages it is a spasm of the muscles which prevents one from dipping into the iliac fossa. Later it is the adhesions between the caecum and the abdominal paries, and occasionally between the omentum and abdominal paries. And, finally, it is the exudate itself. At times two, and at times all three, of these obstructing factors may be present. It is the exception that one of them is found alone. It is only to the first, and afterward to the second, of these factors that I particularly wish to call your attention. The muscle-spasm may be so great and its edges so sharply defined that inspection reveals a fullness, and palpation detects what seems to be an induration. This muscle-spasm may be partially or wholly eliminated by the proper application of the Paquelin cautery. When the patient is fully anaesthetized no trace of the spasm remains. We have seen some cases so early that nothing but the spasm of the muscle has prevented us from dipping normally into the iliac fossa. More frequently, however, in addition to the muscle-spasm there have been adhesions between the caecum and the parietal peritonaeum. It is possible to foretell the presence of these adhesions, in the absence of any considerable exudate (of anything more than a few drops of pus), by palpation of the brim of the pelvis and of the iliac fossa. In this patient the adhesions between the parietal omentum and parietal peritonaeum prevented us from dipping normally into the pelvis on the right side. After separating these adhesions we at once encountered the erect central half of the appendix in cross section. The appendix had been bent upon itself at a right angle or less, and had ulcerated through at about its middle. The peripheral piece was adherent to the ab-

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, December 18, 1893.

Johns Hopkins Hosp. Bull., Balt., 1894, v, 32.

[2] When the patient has general peritonitis and the abdomen is excessively tympanitic the sign to which I refer may be masked.

dominal wall. There was a little pus, three or four drops at most, encapsulated between the abdominal paries and the peripheral end of the central piece and the central end of the peripheral piece of the appendix. A point of great importance in the operative treatment of these cases, and one to which we give perhaps an unusual amount of attention, is the packing off of the uninfected portion of the abdominal cavity from the infected portion prior to opening the abscess, however small this abscess may be. And even when we believe that there is no abscess we pack off the general cavity with just as much care prior to the separation of the adhesions which glue the caecum to the parietal peritonaeum; and, in the absence of such adhesions, prior to separating the adhesions which bind down the appendix. Should pus be present, it is carefully caught and disposed of in such a way that there is perhaps the least possible danger of infecting the general peritonaeal cavity. I fear that I cannot well describe to you our method of packing off and protecting the general peritonaeal cavity. We use a good many sponges of gauze superimposed upon each other in such a way that should the innermost ones become soiled the outermost remain clean. It is well, if possible, to so pack the outermost strips of gauze that they may remain undisturbed and form a part of the final packing of the wound. For adhesions form with surprising rapidity (in a few minutes) which it is undesirable to disturb. We have operated upon thirty-four cases of appendicitis, and without a death if we except the nine perfectly hopeless cases which had acute suppurative peritonitis before they were operated upon. Five cases of appendicitis with a less desperate form of peritonitis were saved by operation.

Of four cases of appendicitis without peritonitis operated upon by me outside of the hospital, all recovered from the disease; and of two with general suppurative peritonitis, both recovered from the peritonitis, but one of them died from haemorrhage about two weeks after the operation and when he was believed to be surely convalescent.

A POSTSCRIPT TO THE REPORT ON APPENDICITIS[1]

Dr. Finney's remarks on the treatment of the wound in cases of appendicitis have been abbreviated so much, as possibly to mislead those who are not familiar with our methods. When he speaks of "leaving the abdominal wound open" he means that the wound is drained with gauze, and not that no attempt is made to close it. The fact is that the wound is sewed up tight about the gauze, so tight that it is sometimes necessary to cut one stitch in order to remove the packing. Whenever pus is encountered either within the appendix or outside of it the wound is drained. Sometimes one or two narrow strips of gauze are sufficient, sometimes very many broad strips are required. Ordinarily all of the gauze is brought out at one point and between stitches which, as I have said, embrace it snugly. The gauze is used not only for drainage, but quite as much to stimulate adhesions between the coils of intestine which surround it and thus effectually shut off the general peritonaeal cavity from its infected portion. The gauze is gently packed about the stump of the appendix, and should reach into every recess of the pus cavity. When the abscess is a large and ramifying one, or when there are several abscesses, we may bring the gauze packing out of the abdomen at more than one point in the wound.

These wounds are closed with mattress sutures; but the sutures are not always buried as they are in all uninfected abdominal wounds which are completely closed and in which the danger of stitch infection is not so great. The stitches, where they are not buried, are prevented from cutting into the skin by pieces of rubber tubing or of gauze. These wounds should be stitched with great care. All of the divided tissues (the peritonaeum excepted) should be included in each stitch unless the stitches are buried. Inasmuch as the muscles retract unevenly the sewing is sometimes a difficult task. If the wound is sewed in this way, and if sufficient care is exercised to avoid the infection of the stitches as they are being introduced and tied, there is little if any danger that a hernia will ensue.[2]

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, April 2, 1894. Johns Hopkins Hosp. Bull., Balt., 1894, v, 113-114.

[2] At the meeting of The Johns Hopkins Hospital Medical Society, November 5, 1894, I presented a case of appendicitis to illustrate our treatment of the incision. Buried sutures of silver wire had been used to bring together the cut edges of the abdominal muscles, and an uninterrupted buried suture of silver wire closed the wound in the skin. The latter suture had already been withdrawn and a fine pink line indicated where the skin incision had been made. A little below the centre of the wound was the orifice of a sinus from which a narrow strip of gauze had just been removed. The cicatrix was three weeks old.

Even the point at which the gauze traverses the abdominal wall is not a weak one. A connective tissue membrane, the wall of the obliterated sinus, extends from the stump of the appendix to this point in the wound and binds the intestines to each other and to the underside of the lips of the open part of the wound. The thickness of this membrane depends principally upon the length of time the gauze is allowed to remain undisturbed. I have found it so strong after ten days that I could with difficulty thrust my finger through it. This membrane atrophies in time. After two years I have found the walls of a sinus to the gall bladder attenuated to little more than a trace.

With our present resources it is not justifiable to attempt to disinfect an abscess cavity of the peritonaeum, no matter how infinitesimally small this abscess may be. Bull and two others, whose names I am not at liberty to mention, are probably not the only ones who have furnished disastrous instances of such attempts.

In operations for appendicitis we have always the strangulated stump of the appendix and usually tissues more or less necrotic in its immediate vicinity as a complication. My experiments [3] demonstrated conclusively the result of inoculation of strangulated tissues in the peritonaeal cavity.

The problem is a very different one when we have an abscess in the cancellous tissue of bone or in highly vascular soft parts to deal with. We may safely close such abscess cavities. If, for example, the so-called pyogenic wall of an abscess in muscle is excised and the parts are then thoroughly washed with an antiseptic solution, we may so far inhibit the pyogenic organisms that the tissues or, if there is a dead space, the prolific granulations, assisted possibly by the blood, may altogether destroy them. In the cancellous tissue of bone a cavity large enough to hold a hickory nut becomes completely filled with granulations in about three days. Blood clots occupying such cavities, if inoculated with virulent cultures of *Staphylococcus aureus,* rarely break down. As a rule, the socalled organization of the clot takes place in from two to four days without suppuration. But an abscess in the peritonaeal cavity is a very different affair because (1) the wall of the abscess consists in part of strangulated or more or less necrotic tissue which we cannot excise; (2) attempts to disinfect such an abscess would probably be futile and might be worse than futile; (3) failure to disinfect might mean general peritonitis and the death of the patient, and not merely the retardation of healing.

There cannot be a definite incision for appendicitis. In general, if there is a large abscess, the incision should be made as near as possible to the crest of the ileum, so as to diminish the chances of entering the clean peritonaeal cavity and to lessen the possibility of a hernia. The muscles are thick in this region, and when divided offer broad surfaces for coaptation by

[3] The Johns Hopkins Hospital Reports. Report in Surgery, I.

suture; and if the incision is too close to the ileum to admit of suture there is little danger of hernia resulting, as we know from a long experience with psoas abscesses, which we open by preference in this region. But the position of the abscess or, if there is no pus or too little pus to be detected, the position of the appendix in the given case should determine the site of the incision. If there is an abscess the tissues over it should be most carefully studied as they are being incised for signs of infiltration with inflammatory products. A little oedema of the deeper muscles (transversalis or internal oblique) may guide us to a circumscribed spot of adhesion of caecum or omentum to parietal peritonaeum and enable us to empty a large abscess without entering the uninfected part of the peritonaeal cavity, or to thoroughly protect the intestines about the encapsulated pus cavity from the danger of infection before the pus is liberated. We place several yards of gauze between the healthy intestines and the abscess before opening the latter.

From a bacteriological point of view, we must often, if not always, inoculate the healthy peritonaeum, but thus far we have not in a single instance had peritonitis supervene upon an operation for appendicitis, nor have we a single death to attribute to the operation. In the case of a large abscess, which we have evacuated without entering the uninfected peritonaeal cavity, we still hesitate to search for and remove the appendix if its removal would necessitate our entering the clean peritonaeal cavity.

When there is little or no pus to be discovered we make our incision directly over the appendix, which can usually be palpated. Here, too, we try to cut through thick muscles if possible. The instant that the peritonaeum is opened, and before it is widely incised, we introduce large towels of gauze, and with these press the intestines over the appendix out of the way and towards the left. When the appendix is nicely exposed and a clear field for operation obtained, we introduce more gauze to serve as an inner lining to the outer ring of gauze. The adhesions which bind down the appendix are then slowly broken up by gentle finger pressure, and if pus is present it is caught as it leaks out by additional gauze sponges. If the inner layer of gauze packing should by accident become soiled it is immediately replaced by fresh packing, the opening into the abscess being meanwhile stopped with a gauze sponge. And so, little by little, the abscess is emptied, and finally the appendix removed. After ligating the appendix and its mesentery we may excise the mucosa which is cut off by the ligature. We never sew up the end of the stump in the infected cases, as some surgeons have advised. This would be a foolish waste of time, for the circulation of the part stitched has been cut off by the ligature applied to the appendix. The gauze for packing is rubbed full of a mixture of iodoform and bismuth and then sterilized.

INFLATED RUBBER CYLINDERS FOR CIRCULAR SUTURE OF THE INTESTINE[1]

Until ten years ago every one who had written on the subject of intestinal suture believed that the Lembert stitches, which were then almost universally used in circular and other sutures of the intestine, included only the peritonaeal coat of the intestine; and many surgeons evidently still believe this. The notions of Jobert and Lembert as to the structure of the intestinal wall were still accepted by all surgeons. The submucous coat of the intestine, the coat which, I am convinced, should most concern the surgeon when he is sewing the intestine, was ignored or unknown. In my first article on suture of the intestine[2] in 1887 I quoted from Madelung[3] as follows: "The needle now penetrates in the usual manner the two ends of the intestine, passing between serosa and muscularis"; and from Reichel,[4] who insists upon the "accurate adaptation of the two edges of the wound, particularly of the two serous coats," and having described the manner of taking the first row of stitches, continues, "over this then comes the external suture, which includes only the serosa." Maydl, Kocher, Czerny and others were quoted to show that the submucous coat had not been recognized, and how universal was the opinion that intestinal suture should be performed by stitches which included only the peritonaeal coat. When we know that the wall of the intestine must be magnified to a thickness of 4 cm. to enable us to represent the peritonaeal coat by a fine pencil-stroke, we find it hard to understand that surgeons should ever have supposed that they were including nothing but peritonaeum in their stitches. Hardly less remarkable is the fact that the intestinal wall had, for the surgeon, only three coats—the serous, muscular, and mucous coats. Not only were the qualities of the submucosa unknown to surgeons, it was also an unknown quantity. Only five years ago Schimmelbusch,[5] describing with some detail the manu-

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, December 13, 1897.

Johns Hopkins Hosp. Bull., Balt., 1898, ix, 25-27.

Also: Phila. M. J., 1898, i, 63-68. (Reprinted.)

[2] Halsted: Circular Suture of the Intestine. An Experimental Study. Am. Jour. Med. Sciences, October, 1887.

[3] Madelung: Arch. f. klin. Chirurgie, Bd. xxvii, p. 321.

[4] Reichel: Deutsche Zeitschr. f. Chirurgie, Bd. xiv, pp. 268 and 270.

[5] Schimmelbusch: Anleitung zur aseptischen Wundbehandlung, Berlin, 1892, p. 104.

facture of the so-called catgut, tells us that it is made from the longitudinal muscular coat. He says, "If the intestine be laid on a towel and scraped with a dull instrument like the back of a knife, the muck ('Schmutz'), so called by the artisans, is removed. This is nothing else than the mucous membrane of the gut. In the same manner the circular muscular coat is rubbed off, so that only the very thin tube composed of longitudinal muscle-fibres remains, an intact, very delicate and pipe-like structure which may be distended with air. The threads are manufactured from this by twisting, and conformably to the thickness desired, either the entire tube or only strips of it are twisted together like hempen cords." The muscular pipe referred to is, of course, the tube of the submucosa, the sausage-skin, etc.

The following suggestions, emphasized among others, in my article on intestinal anastomosis,[6] are equally relevant to circular suture of the intestine:

"1. It is bad surgery to employ stitches which enter the lumen of the intestine.

"2. It is impossible to suture the serosa alone.

"3. It is impossible to suture unfailingly the serosa and muscularis alone, unless one is familiar with the resistance offered to the needle by the submucous coat of the intestine; furthermore, stitches which include nothing but the serous and muscular coats tear out easily and are not to be trusted.

"4. Each stitch should include a bit of the submucosa. A fine thread of this coat is much stronger than a considerable shred of the entire thickness of the serosa and muscularis. It is not difficult to familiarize one's self with the resistance offered to the needle by the submucosa, and with a very little practice one learns to include a bit of this coat in each stitch.

"5. The mattress-stitches are to be preferred to Lembert's, because one row of them is sufficient, because they tear out less easily, oppose larger surfaces and more evenly, and constrict the tissues less than the Lembert stitches do."

6. In circular suture of the intestine, only one row of stitches should be taken, and the entire row should be applied before a single stitch is tied; otherwise it is impossible to preserve a straight line in the taking of the stitches, and the stitches taken last may be never so much farther from the cut edge than those taken first, and the flange turned in may be so broad as to occlude the intestine's lumen.

7. Before the intestine is resected, its blood-supply should be most carefully studied, with reference not only to the placing of ligatures, but also of

[6] Halsted: Intestinal Anastomosis. Demonstration at a meeting of The Johns Hopkins Hospital Medical Society, December 1, 1890. Johns Hopkins Hospital Bulletin, January, 1891.

the stitches, and the stitches should be so placed that the circulation, up to the very edge of the parts to be sewed, shall be as perfect as possible.

The results obtained by adhering strictly to the foregoing rules have been so perfect [7] that we have employed no other methods in our practice.

Edmunds and Ballance in their valuable contribution [8] to intestinal surgery, give the results of their measurements to determine the relative thickness of the submucous and muscular coats in the dog and in man. They state that the muscular coat is very much thicker in the dog than in man, but that the submucous coat is somewhat thicker in man than in the dog, and they too find it perfectly feasible to engage a thread of the submucosa in each stitch without perforating the lumen of the intestine.

The objection to Neuber's [9] decalcified bone-bobbins, Senn's decalcified bone-plates, and Murphy's button, probably the best of the mechanical aids to intestinal suture, I will not dwell upon at this time. The method of each of these surgeons has its advantages, particularly in the hands of those who have not practised the intestinal sutures on animals.

I believe that the license to practise general surgery should be withheld from those who have not practised on animals the operations for circular suture of the intestine and intestinal anastomosis.

Not so very long ago a surgeon requested me to assist him to perform a circular suture of the intestine (end to end anastomosis) upon one of his patients. He readily consented to practise the operation upon dogs. At first his dogs died. He finally succeeded in saving more than 50 per cent of the dogs operated upon. The operation upon his patient required five hours, but was successful. It is not difficult to predict what the result would have been if the practice on dogs had been omitted.

Experts in intestinal surgery, almost without exception, prefer to perform circular suture of the intestine without the use of mechanical devices.

[7] Amer. Jour. Med. Sciences, October, 1887.

[8] W. Edmunds and Charles A. Ballance: Observations and Experiments on Intestinal and Gastro-intestinal Anastomosis. Medico-Chirurg. Trans., Vol. 78, London, 1896.

[9] A few weeks ago Dr. Mitchell discovered in the *Medical and Surgical Reporter* for July, 1896, a description by Dr. A. J. Downes, of collapsible rubber bobbins for all forms of intestinal approximation. These bobbins resemble Neuber's bobbins very closely and were designed with the same end in view, viz., to accommodate the inverted ends in circular suture of the intestine. My rubber cylinders were made in June, 1897, and were suggested to me by the success attending the employment, experimentally, of aluminum rods in suture of the common bile-duct. I intend to describe these rods at another time. Dr. Downes' bobbins have spherical ends, which are filled with water. When a larger is to be sutured, end to end, to a smaller intestine he uses a bobbin especially designed for the purpose, with a large sphere at one end and a small sphere at the other end of the connecting shank. I should suppose that this modification of the bobbin would defeat the very end for which it was constructed.

But my operation was not by any means a satisfactory one, notwithstanding the very perfect results which attended its employment in the hands of others as well as myself.

The disadvantages of my original method and of all similar methods (methods without mechanical aids) were as follows:

1. They required about twenty minutes to perform the operation.
2. One or two assistants at the wound were indispensable.
3. Clamps or the fingers of an additional assistant were necessary to prevent the escape of intestinal contents.
4. The vermicular action of the intestine (particularly in dogs) was a great annoyance, for it prevented an accurate disposition of the stitches; stitches applied as near together as possible during intestinal contraction might be too far apart in the stage of relaxation.
5. If the pieces of intestine to be united were not of the same size their adjustment might be very difficult.
6. The rolling out of the cut edges of the intestine prevented in places recognition of the precise edges, and hence the operator might not know just how far from the edge he was placing his stitches nor just how much intestine he was turning in.
7. The handling of the intestine by assistants who act as clamps or who holds parts in place during the stitching must be injurious to the tissues and predispose to infection.

Every one of these objections is disposed of by the employment of the rubber cylinders in the manner indicated in the plates. The drawings are so excellent and illustrate the method so graphically and accurately that a description of the procedure is almost superfluous.

Plate IX and Plate X, 1, show the presection-stitches applied. It is immaterial whether these stitches perforate the wall of the intestine or not, for they are cast off eventually into the bowel. The method of ligating the mesenteric vessels is also accurately shown in Plate IX and Plate X, 1, which were drawn from life. The intestine should be divided carefully with scissors as close to the presection-stitches as possible. No visible blood-vessels are occluded by these stitches.

Plate X, 2. The rubber cylinder inflated. For the human small intestine the diameter of the cylinder is from 1¼ to 1½ inches. It would be better to have cylinders larger than necessary rather than too small.

In Plate XI two of the presection-stitches have been tied, and the collapsed rubber cylinder is being pushed into the bowel with a forceps.

Plate XII. The three presection-stitches have been tied. They are supplemented by a fourth stitch, *b*, which is removed later to facilitate the withdrawal of the bag. The bag has been inflated with air by the syringe. Water

might, of course, be used instead of air; but a bag distended with air would, perhaps, more quickly reveal a prick from a faulty stitch than a bag distended with water.

The stitch *a* (Plate XIII, 1, and also Plate XII, Plate XIII, 2, and Plate XIV, 1) is the first and most important of the mattress or permanent stitches. The submucosa is picked up four times by this as by all the mattress stitches, and the mesentery is twice perforated by it (Plate XIII, 1). This stitch insures the proper turning in of the mesenteric border. It was devised by Drs. Mitchell and Hunner, and I shall call it the Mitchell-Hunner stitch.

Plate XIII, 2. The bag is still distended, and all of the mattress stitches have been placed. From seven to nine of these stitches suffice in operations upon the small intestine of the dog, and from ten to twelve in operations upon the human subject. The first stitch to be drawn home and tied is *a*. The mesenteric border is turned in by it infallibly. *Not a single visible vessel is occluded by the stitches* (Plate XIII, 2, and Plate XIV, 1). On the right side the stitches pass under one vessel and over another, without interfering with either, and on the left side a vessel lies under the stitches, uninjured.

Plate XIV, 1. Two mattress stitches drawn aside on a hook; the temporary stitch has been removed and the collapsed bag is being withdrawn.

Plate XIV, 2. The circular suture is completed; the slit in the mesentery is being sewed in such a way that its circulation is not interfered with.

Advantages of the Inflated Rubber Cylinder in Circular Suture of the Intestine

1. The vermicular action of the bowel is arrested over the bag, and the stitches can, consequently, be placed at regular and proper intervals.

2. The distended bag unrolls and spreads out to a fine edge the everted raw edge of the intestine (Plate XI), and enables the operator to place the stitches with great precision at the desired distance from this edge.

3. If distended intestine is to be sutured to collapsed intestine (in strangulated hernia, ilius, etc.), or intestine of larger to intestine of smaller lumen (jejunum to ileum, duodenum to esophageal end of the stomach, etc.), the smaller may easily be expanded to fit the larger piece.[10]

[10] I have recently had occasion to unite a distended paper-thin jejunum to a collapsed ileum. The rubber cylinder worked like a charm. The patient, a very old and feeble woman, convalesced without interruption for 16 days. She died quite suddenly from peritonitis due to complications which cannot at this time be discussed. So far as the stitching was concerned the result was perfectly satisfactory.

4. Very little handling of the intestine itself by the operator is necessary. The tube from bag to syringe is used as a handle to rotate and elevate the parts to be united.

5. The cylinder takes the place of at least two assistants. The operation could readily be performed without an assistant.

6. It prevents escape of intestinal contents and hence dispenses with the injurious clamps or the fingers of assistants.

7. The entire operation, exclusive of suture of the abdominal wall, can be performed on dogs in five or six minutes and probably in less time.

The results should, I believe, be better than by any method hitherto devised.

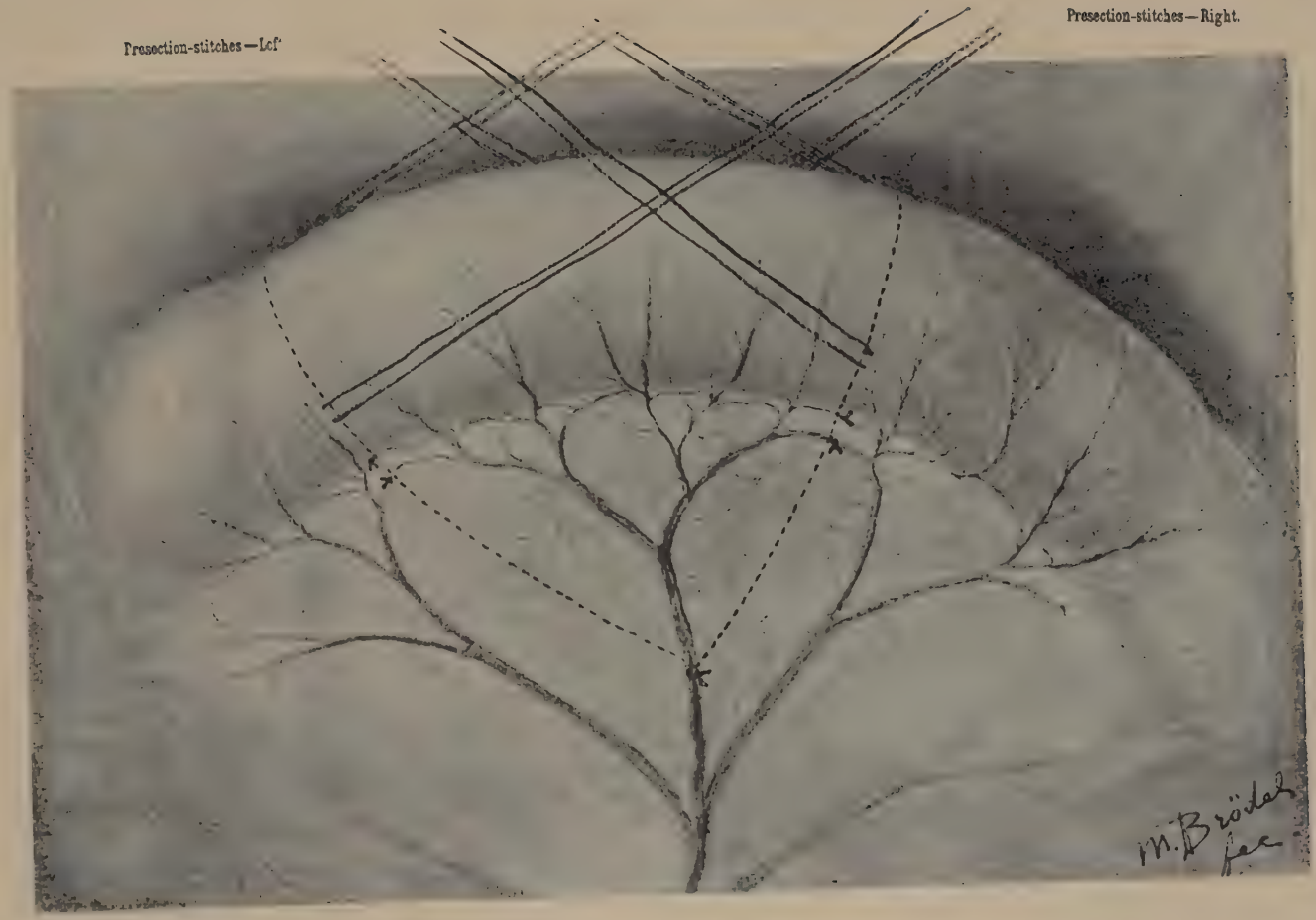
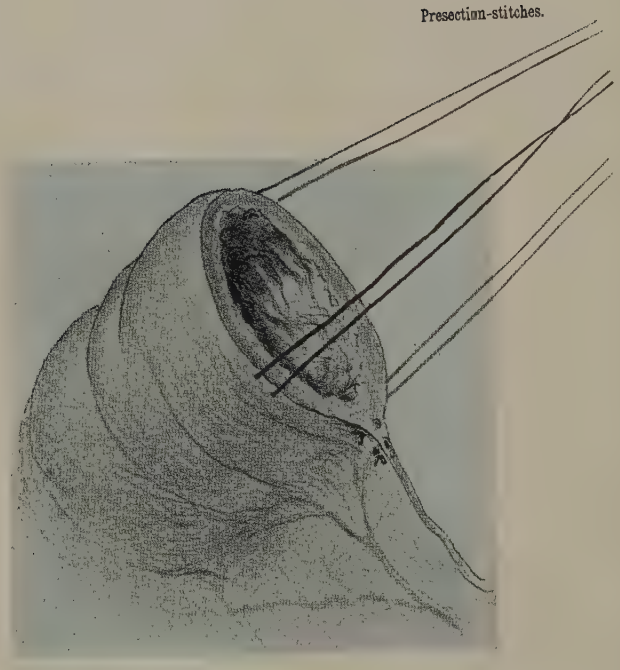

Presection-stitches—Left
Presection-stitches—Right.
M. Bröder fec

PLATE IX

PLATE X



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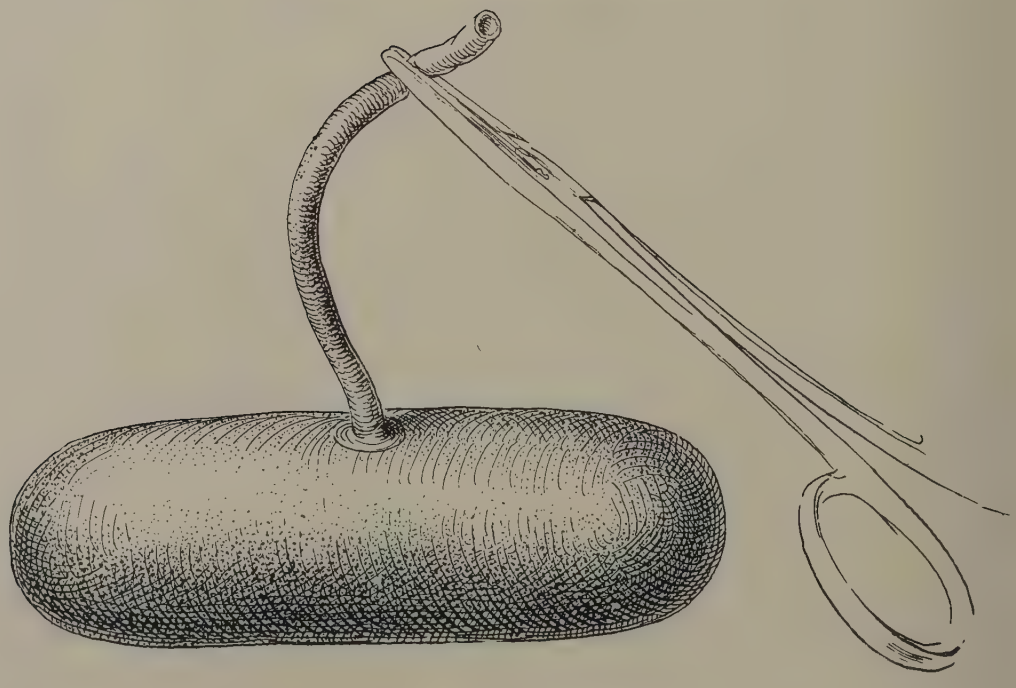

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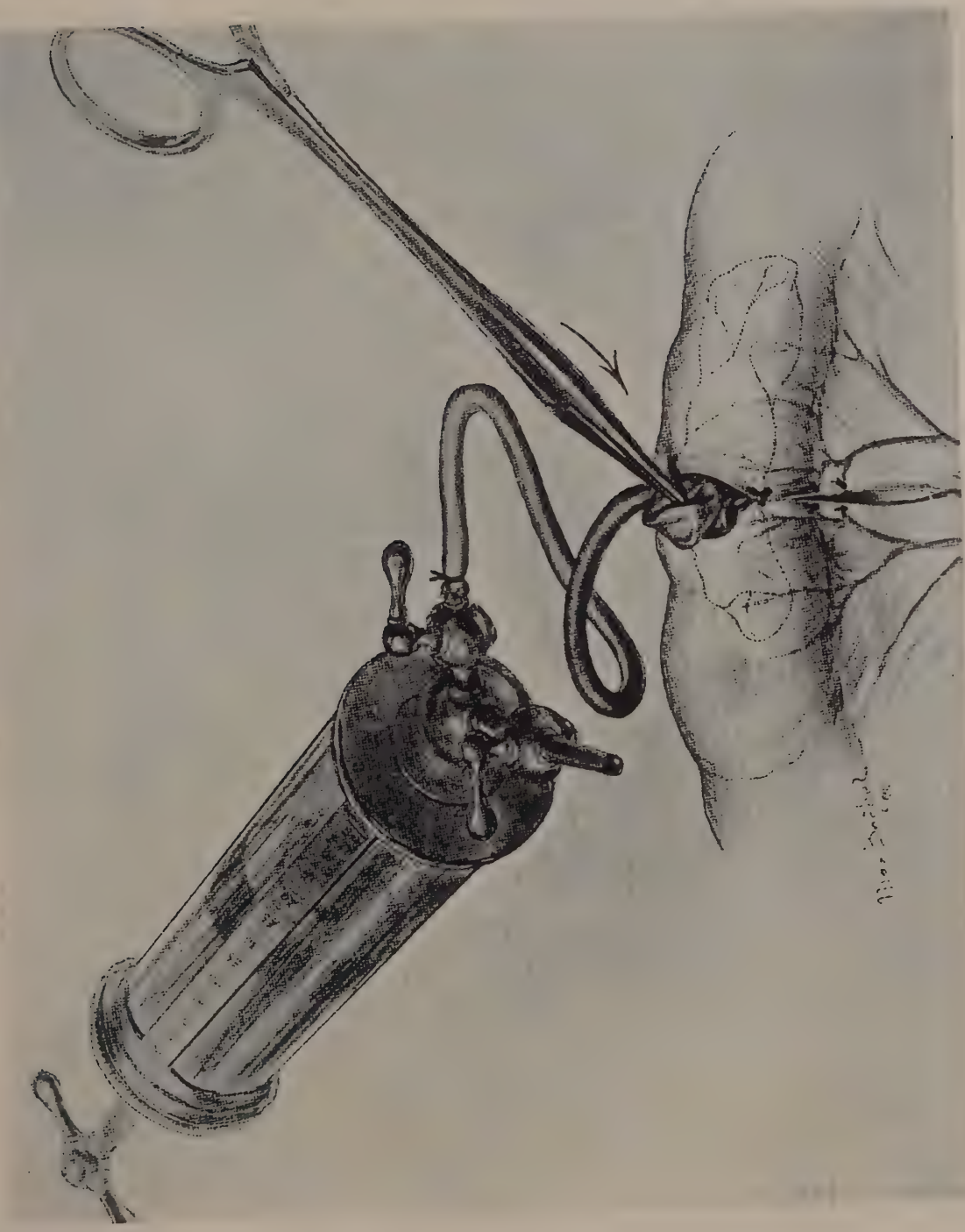
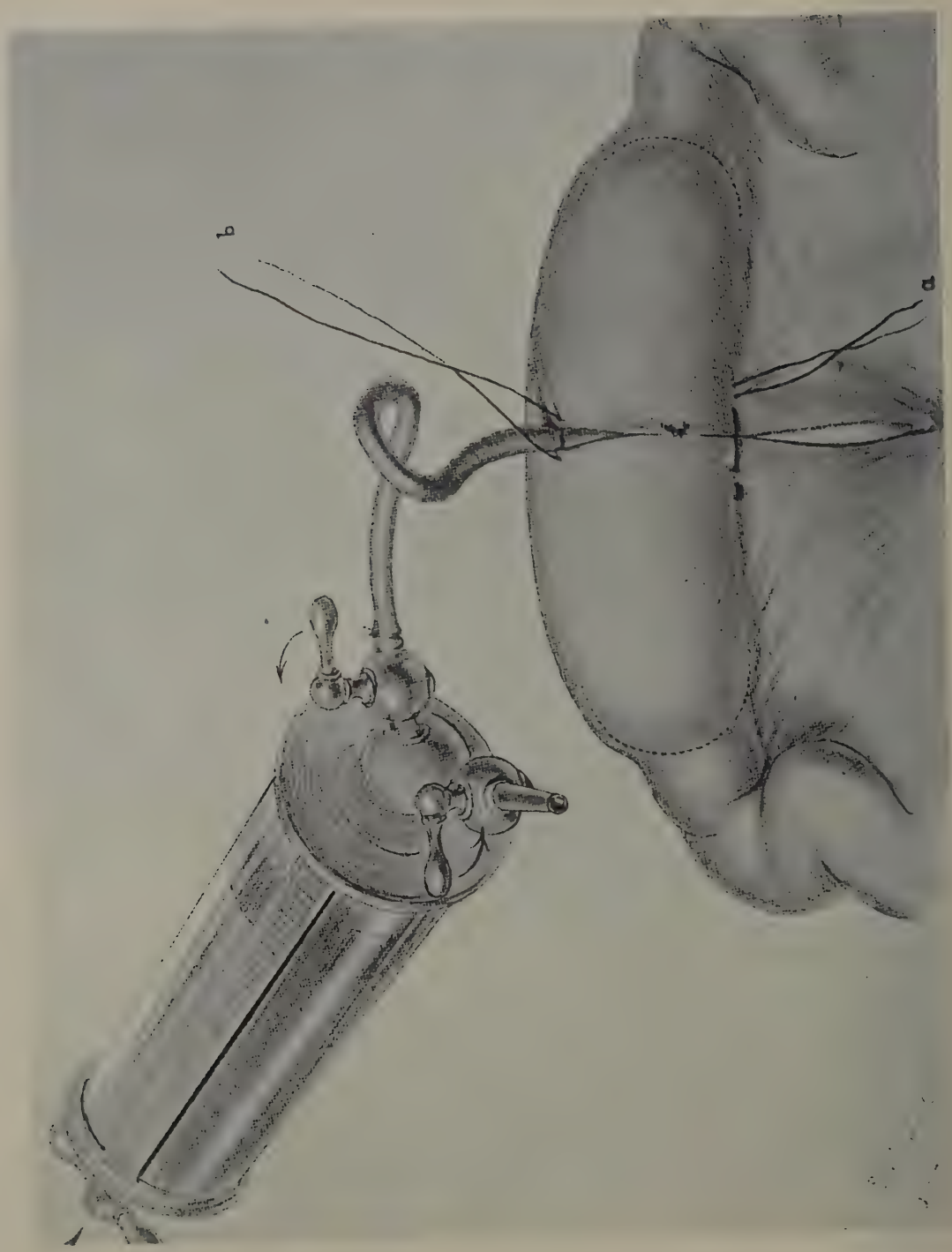
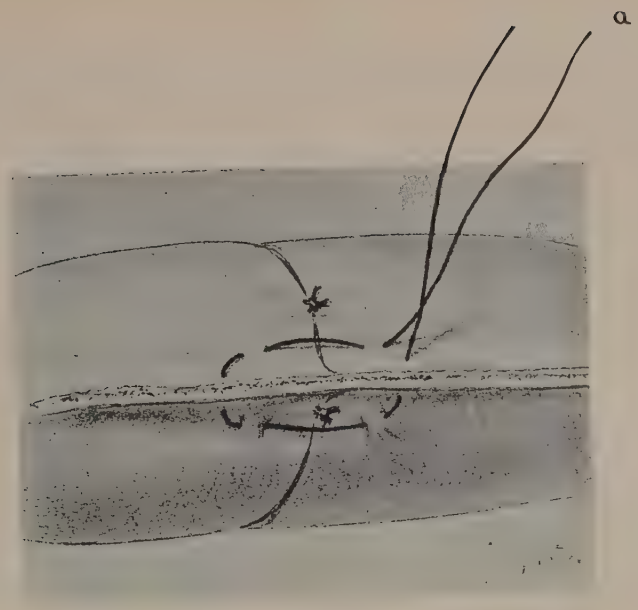


PLATE XII





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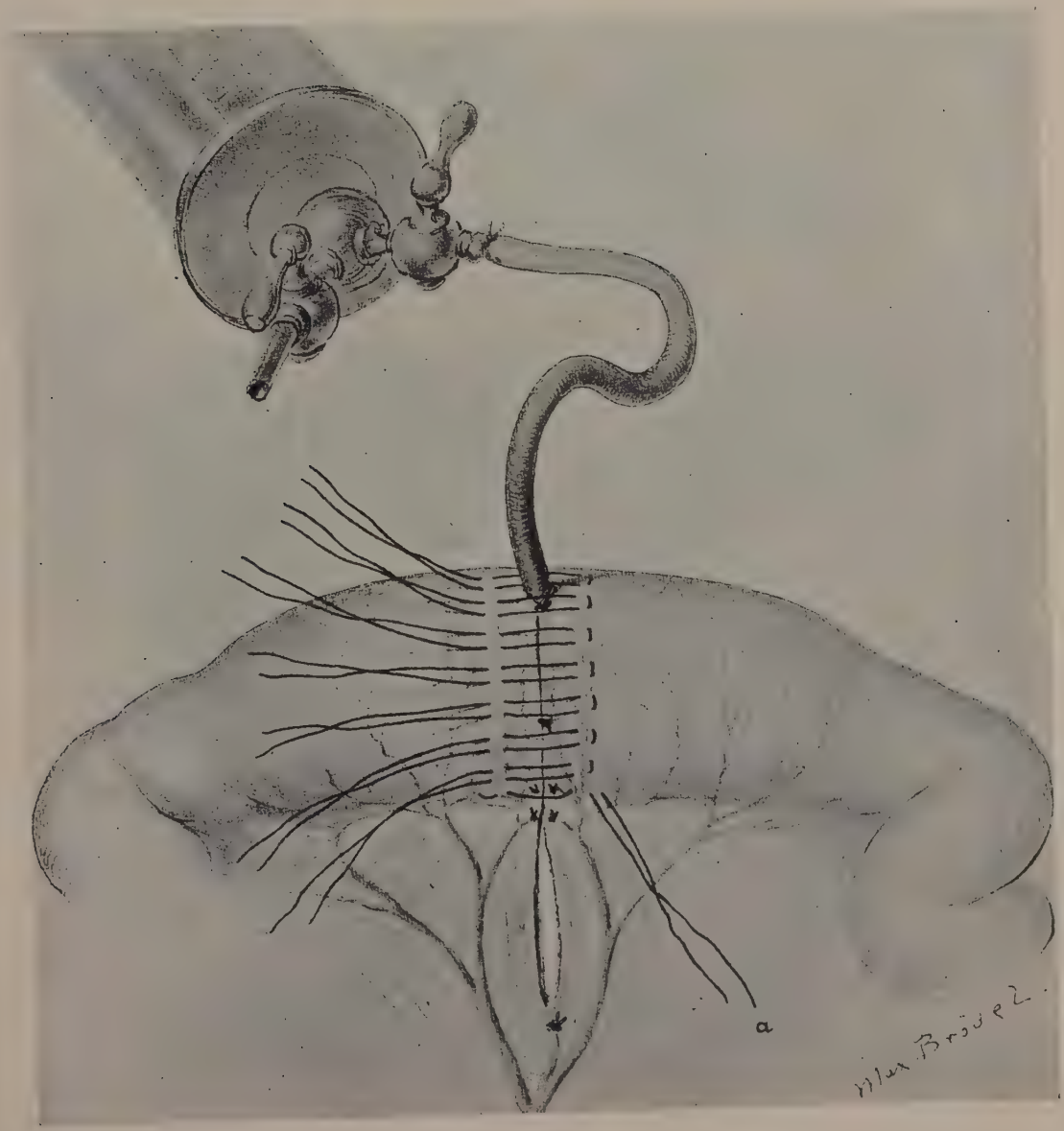

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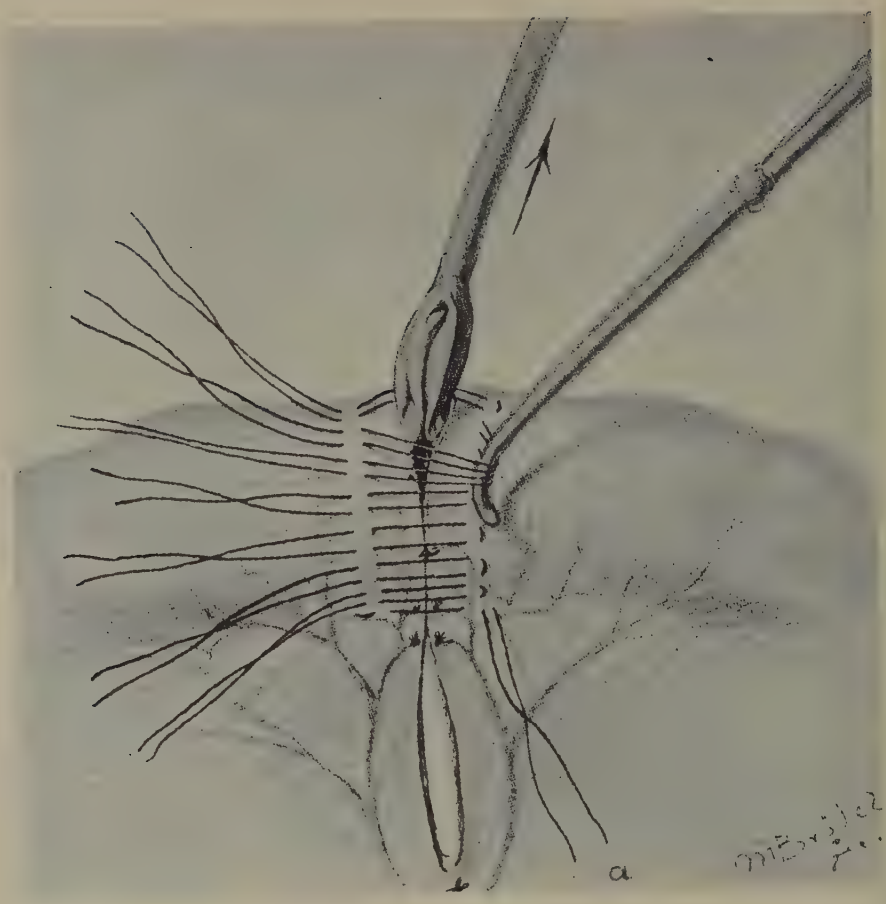
PLATE XIV



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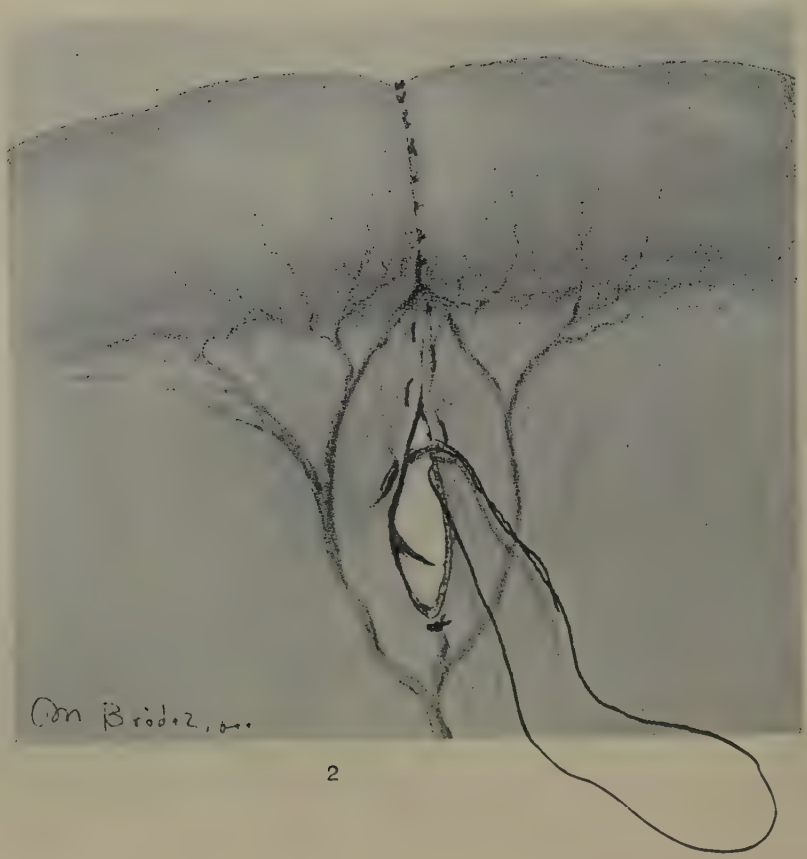


2

END-TO-END SUTURE OF THE INTESTINE BY A BULKHEAD METHOD[1]

PRELIMINARY COMMUNICATION

Soiling is undoubtedly an important contributing factor in the mortality attending end-to-end suture of the large bowel, but it will not definitely be known just how important this factor has been until it can be entirely eliminated. Of the various methods devised to avoid the escapement of intestinal contents during the operation of circular resection of the intestine, those of Parker and Kerr and of Moszkowicz deserve especial mention. If the basting stitch feature of the Parker-Kerr operation were altogether omitted, and the walls of the gut brought together by the first row of sutures over the narrow clamp which these surgeons have devised, their operation and that of Moszkowicz would be almost identical. I have sent to Vienna for the Moszkowicz clamps, and may at another time be able to report results of trials on man and animals of these beautifully constructed instruments.

For the large intestine the circular suture or end-to-end anastomosis would, if equally safe, be conceded to be the ideal method; occasionally it is the only feasible one in cases of resection of the large bowel.

The problem of making an end-to-end anastomosis in a manner more nearly ideal has, for the past six or eight months, been for me a constantly recurring one. There has been a fascination in the difficulties presented by it. Repeatedly certain steps of the problem, which have seemed to be solved on paper, have proved on experimentation to be much more difficult of solution than had been supposed.

As to the mere exsection of, say, a loop of bowel, this can be carried out as cleanly and as aseptically as the resection, for example, of the appendix. Did it suffice merely to sew together the abutted ends of the gut, each end having been treated after the manner of an appendix stump, the problem would seem to be solved. The intestinal wall having been crushed and reduced to its submucosa, firmly ligated and divided with the Paquelin cautery, the division of the gut is aseptically accomplished. The two free ends can now be abutted and sutured without manifest flaw in the technique. But a double diaphragm remains which would impede for a long time the

[1] Presented at the American Surgical Association, Washington, D. C., May 3-5, 1910. Tr. Am. Surg. Ass., Phila., 1910, xxviii, 256-261. (Reprinted.)

passage of intestinal contents, even if the ligatures employed in the tying off of the gut could be relied upon to melt away or disappear in a desired period. In other words, the amount turned in of the intestinal wall by such a method is too great.

These diaphragms, which in some of our experiments were reduced to the submucosa, may be charred by the cautery [2] in such a manner that they will ultimately slough away, but the process of separation of tissue so dense is very slow, and the time required for its accomplishment uncertain. One experiment was made by this method; the dog recovered without symptoms of obstruction, and is now in good health. But a satisfactory result could not be expected uniformly to attend such procedure.

To eliminate this diaphragm, I devised a sharp-edged punch, with the idea of introducing it at a higher point in the bowel through a lateral opening, slipping it down to the diaphragm, and, pressing it through this obstruction and into a cork introduced per anum, to withdraw both cork and punch by means of a string attached to the former. This method was not tested, for at this juncture Dr. Gatch, who has assisted me in all these experiments, came to the rescue with a suggestion much better, altogether novel, and one which may prove to be the key to the best solution for this particular form of procedure. He proposed that the bowel ends, invaginated over a contrivance like, for example, the Harrington collapsible hammer, be redivided by the cautery beyond an encircling ligature which should bind the gut firmly to the hammer. The end-to-end suture would then be made, and finally the hammer collapsed.

To invaginate and redivide the gut seemed to me a very happy thought and one which promised well for the disposition of the diaphragms. It was obvious, however, that the hammer was not the ideal device for the purpose. It appeared desirable that each of the divided intestinal ends should be treated independently of the other, for only in this way could the surfaces be properly approximated for suturing. If tied to a hammer-like device, the ends of the bowel after having been burnt would not only not be in contact, but would be separated by an interval so great as to prohibit the employ-

[2] Four or five years ago, during the house-surgeonship of Dr. W. F. M. Sowers, and with his assistance, I performed one or two gastro-enterostomies on the human subject with the aid of the Paquelin cautery. The posterior rows of stitches having been taken, the muscular coats of stomach and intestine were divided and stripped back so as to allow of sufficient exposure of the submucosa. This coat was then burned with the cautery, but I was in neither instance altogether satisfied as to its destruction until I had actually perforated it with the Paquelin, and so defeated the end in view, which was to avoid entering either bowel concerned in the anastomosis in the course of the operation.

ment of a continuous stitch for the reason that the turning in of too much bowel would be necessitated. Nor could an interrupted suture be used with the idea of collapsing the hammer before the stitches were drawn home, because with the disjunction of the hammer the encircling ligatures would be loosened, and thus the protecting, invaginated diaphragms be freed, and the escape of intestinal contents, and hence soiling, permitted.

Rings of very thin metal were tested. These were made broad enough to admit of being deeply grooved or guttered on the circumference for the reception of the bowel with its confining ligature, and were equipped with a little radial spur within to facilitate holding and so prevent their rotation. But, for the crushing of the rings with a concavo-convex rim, even of lead ones, too great force was required, a force which occasioned trauma of the bowel. Furthermore, the tendency on compressing the rings was, of course, to an elliptical form, which did not permit the disengagement of the encircling ligatures; and the indenting or sectoroid form of collapse was attained only with greater damage to the bowels. And even when indentation of the rings was satisfactorily accomplished, they were not easily released from the embrace of the encircling thread.

So we gave our attention to soluble rings, and Dr. Gatch produced hard disks of sugar, thick lozenges, which he had grooved on the edge. We experienced, however, great difficulty in engaging these with the ligature. The intestinal peristalsis and the slipperiness of the peritonaeal surfaces and of the moistened sugar contributed to the difficulty of maintaining the plane surfaces of the sugar disk at right angles to the long axis of the bowel.

It then occurred to me to produce the invagination by means of a soluble cylinder or rod, which, grooved at regular intervals for the reception of the doubled wall of the gut, might, with the Paquelin cautery, be burned through together with the folded gut. Sticks of candy and of extract of licorice, being easily available, were employed, and the result of the first trial with candy was encouraging. The division with the cautery being easily and accurately accomplished, each end of the bowel was thus securely plugged with what might be termed a bulkhead of sugar; these warm, sticky bulkheads were pressed together, and, adhering to each other with considerable firmness, possibly assisted the act of suturing, which happened to terminate precisely at the moment that the sugar cylinders had melted sufficiently to liberate the finger-cot-like diaphragms or invagination of bowel. So we congratulated ourselves on the success of our bulkhead method. Our satisfaction was of short duration, for at the next experiment, performed a few days later, we were not so lucky in engaging the grooves either on the candy or licorice sticks. So I decided that it would facilitate the execution of the procedure to have a soluble cylinder provided with a number of flanges, for

no difficulty could be experienced in binding the gut to the cylinder between two of these flanges. The gut and cylinder might then be divided close to the ligature.

After having a brass model constructed to serve as the positive for the mould, it occurred to me that it would greatly simplify matters, doing away with the necessity for a mould, to make the flanges of rubber—these to be slipped on a smooth cylinder. So rings were cut from a catheter of the proper size and sticks of candy were armed with these as flanges. Thus another difficulty was overcome.

But the procedure needed refinement. It would be better to eliminate the burning of so much sugar or other materials of which the stick might ultimately be composed. A hollow cylinder would, I thought, be preferable to a solid one. But how to prevent the too sudden collapse of such a tube was the question. We might mount closely fitting gelatin capsules on metal mandrils, over all draw the rubber flanges, and, burning through the gelatin, remove, on completion of the suture, the supporting mandrils. We made trial of gelatin capsules heavily coated with shellac to prevent them from dissolving too rapidly, and supported them on snugly fitting mandrils. But the heat of the cautery made them adhere so firmly to the brass mandrils that they could not be dislodged nicely; and the capsules, when employed without the mandrils, softened on the application of the cautery knife, and hence lost the required firmness. So the licorice, which we found could be turned on a lathe, was again resorted to, this time in the form of grooved rods. The determination, even through a thick intestinal wall, of the situation of a groove is made easy by the use of rubber bands placed close behind the edges of the grooves. As the ligature encircling the invaginated bowel in front of the rubber flange is being drawn tight, the invaginating rod is drawn outward until its band, having been brought into proper relation with the ligature, compels the latter to find the groove. In the taking of the stitches, which may be continuous or interrupted, as preferred by the operator, one must not, of course, include in them the invaginated portion.

With the recognition of this danger, such mishap may with certainty be avoided by sliding into place, with the fingers, the surfaces to be brought in contact for suturing. The support furnished by the still undissolved bulkheads makes it possible for the assistant to perform this act of further invagination with great nicety; furthermore, tug on the intestinal wall, incident to the taking of each new stitch of the continuous or interrupted variety, and which is ordinarily exerted in drawing surfaces of intestine into contact by stitching, is avoided by this act of sliding the bowel walls into the desired position.

Our experiments, though uniformly successful with the above described method, have not been sufficient in number to justify our unqualified endorsement of it.

I would again call attention to the importance of the submucosa as a coat to be included in all the stitches, and to the desirability of avoiding, as much as possible, penetration into the lumen of the bowel in the taking of the suture.

A BULKHEAD SUTURE OF THE INTESTINE[1]

It would, I think, be conceded that end-to-end anastomosis of the intestine should be the method of choice if it were as safe as the lateral anastomosis. Occasionally the circular suture is the only feasible one.

Soiling, unquestionably, contributes to the mortality attending the circular suture, particularly of the large bowel, but how important this factor is cannot be definitely determined until it shall have been completely eliminated.

The problem of making an end-to-end anastomosis in a manner more nearly ideal, namely, in truly aseptic fashion, has for many years confronted surgeons, but only during the past two years, and since having had in mind some investigations involving the making, simultaneously, of a number of resections of the gut have I given the matter serious consideration. In experimentation of this kind, the failure of one suture means disaster to all, and the loss perhaps of half a day's work.

That the solving of this problem is also worth while from the humanitarian point of view is indubitable. In the winter of 1909-10, assisted by Dr. Willis D. Gatch, I made a number of experiments on dogs in the hope that we might contribute something toward the solution of this problem which became the more fascinating as the difficulties presented by it increased. Repeatedly certain steps in a procedure which seemed on paper and at night to be solved could be found, when tested at the operating table in the morning, to be as far from solution as ever.

As to the simple excision of a loop of bowel, this can be carried out as cleanly and as aseptically as the resection of the appendix. If it sufficed merely to sew together the abutted ends of the gut, each end having been treated after the manner of an appendix stump, the problem would seem to be solved. The wall of the bowel having been reduced to its submucous coat by crushing or otherwise, firmly ligated, and cut through with the Paquelin cautery, the division of the gut is accomplished aseptically. The two free ends can now be abutted and sewed together without manifest flaw in the technique. But a double diaphragm remains to impede for a long time the advance of intestinal contents even if the ligatures employed in the tying off of the gut could be relied upon to melt away with the desired promptness. In other words, the amount turned in of the intestinal wall is too great.

[1] Received for publication January 16, 1912.
J. Exper. M., Lancaster, Pa., 1912, xv, 216-224. (Reprinted.)

Diaphragms like these, which in some of our experiments were reduced to the submucosa, may be charred by the cautery in such a way that they will ultimately slough, but the process of separation of tissue so dense is too slow. One experiment was carried out on this plan. The animal recovered with the aid of a prolonged fast without symptoms of obstruction. But a satisfactory result could not be expected uniformly to attend such procedure.

Only a few experiments had been undertaken when Dr. Gatch made a suggestion which is altogether novel and may prove to be the key to the situation. He proposed that the bowel ends, occluded in the described manner, be invaginated over a contrivance like the Harrington collapsible hammer and redivided by the cautery beyond encircling ligatures which should bind the gut firmly to the instrument. The end-to-end suture would then be made and the hammer ultimately collapsed.

To invaginate and redivide the gut seemed to me to be a particularly happy idea and one which promised much toward the elucidation of the whole problem. It was obvious, however, that a contrivance of the order of the hammer could not be suitable, for the invaginated ends, after having been burned away, would be too far apart for the act of stitching them together. An instrument might, I grant, be devised which would admit of the approximation of the seared ends, but I think it would be better for various reasons to be able to treat each gut-end separately. On a hammer-like instrument one could not, for example, invaginate the gut indefinitely nor, having burned off the ends beyond the ligatures, repeat the process at another point should there be indications for this.

Believing, therefore, that it was desirable to be able to treat each of the ends separately, rings of very thin soft metal were tested. These were made broad enough to carry a groove on their circumference for the reception of the bowel with its confining ligature and were provided with a little radial spur, within, to facilitate the holding of the rings. But for the crushing of the rings, even of lead ones, with their concavo-convex rims, the force required was so great that it occasioned trauma of the bowel.

Furthermore, the tendency on compressing the rings was, of course, to an elliptical form which did not permit the disengagement of the encircling ligatures; and the indenting or sectoroid form of collapse was attained only with still greater damage of the intestine. And even when indentation of the rings was satisfactorily accomplished, they were not easily released from the embrace of the binding threads.

Then we tried soluble rings, and Dr. Gatch provided hard disks of sugar—thick lozenges which he had grooved on the circumference. We experienced, however, great difficulty in engaging these with the ligature. The intestinal peristalsis and slipperiness of the peritonaeal surfaces and of the moistened

sugar contributed to the difficulty of maintaining the plane surface of the sugar disk at right angles to the long axis of the bowel.

At last it occurred to me to produce the invagination by means of a soluble cylinder or rod which, grooved at regular intervals for the reception of the doubled wall of the intestine, might be burned through together with the invaginated gut. Sticks of candy and extract of licorice, being easily available, were employed, and the result of the first trial with candy was encouraging. The division with the cautery being easily and accurately accomplished, each end of the bowel remained securely plugged with what might be termed a *bulkhead* of sugar. These warm, sticky bulkheads were pressed together and, adhering to each other with considerable firmness, possibly assisted the act of suturing, which happened to terminate precisely at the moment that the sugar had melted sufficiently to liberate the finger-cot-like diaphragms or invaginations of the bowel wall.

Our satisfaction was of brief duration, for at the next experiment we were not so lucky in engaging the grooves on the sticks, whether of candy or licorice, so I decided to arm the cylinder with a number of flanges which might easily be palpated through the wall of the intestine, being confident that no difficulty would be experienced in binding the gut to the cylinder between two of these flanges.

After having had a brass model constructed to serve as the positive for mould, it seemed to me that it would greatly simplify matters, discarding the mould idea, to make flanges of rubber—these to be slipped on a smooth, soluble cylinder.

So rings of rubber were cut from a catheter of the proper size and sticks of licorice armed with these as flanges.

Thus another difficulty was overcome. But the procedure was still in need of great refinement. A hollow cylinder would, I thought, be preferable to the solid ones, for the burning of a solid rod of licorice or sugar was a disagreeable and clumsy performance. Hollow cylinders of hard gelatin coated with shellac were mounted on brass mandrels, over all were drawn the rubber rings, and the gelatin was burned through to the brass mandrels. But the heat of the cautery made the gelatin adhere to the mandrels so that the latter could not be nicely dislodged; and the capsules when employed without the mandrels lost the required firmness on being cut through with the cautery knife.

Then the licorice was again resorted to. I found that it could be turned in perfect cylinder form and also grooved on a lathe. Close to the edge of each groove on the licorice rod, a rubber flange was placed. The determination of the situation of each groove was made easy by the use of the rubber bands which could be distinctly felt through the intestinal wall even when

peristalsis was taking place. As the ligature encircling the invaginated intestinal wall in front of a rubber flange was being tightened, the invaginating rod of licorice was slowly withdrawn until the ligature became engaged in the groove intended for it, as it was compelled to do by the rubber flange.

The procedure had reached this stage in its development when, at the meeting of the American Surgical Association in the spring of 1910,[2] I reported the progress which had been made.

Since then the method has been decidedly improved by the substitution of paper cones for the licorice rods.

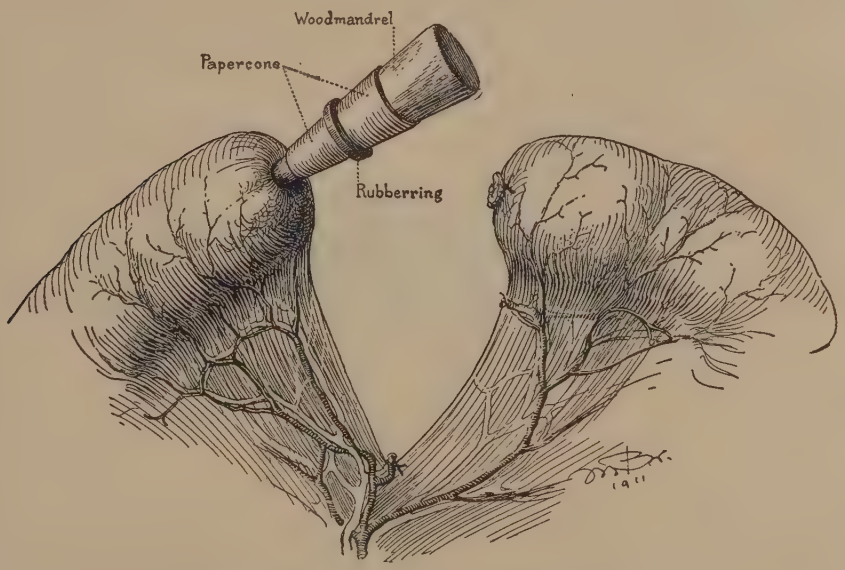


FIG. 30.—One of the Ends of the Divided Gut is Being Invaginated by the Wooden Mandrel Which Carries the Paper Cone.

Cones of any desired size and thickness can be manufactured in a few minutes by twisting and pasting together narrow strips of paper, one after the other, on a conical form of wood, the latter to be used later as a mandrel. The paper cones are armed, each with a rubber flange or ring cut from a catheter.

The operation is then performed as follows: The peritonaeal and muscular coats are divided and stripped back on the submucosa far enough to enable the operator to place two ligatures around the gut and to divide between these with the hot knife. To prevent the slipping of these ligatures which are of fine silk, and threaded on straight needles, they are made to

[2] Tr. Am. Surg. Ass., Phila., 1910, xxviii, 256-261. [W. C. B.]

engage, but not completely pierce, the submucosa at, say, three or four points before being tied.

The paper cone armed with the rubber ring and mounted on the mandrel of wood is carried by the latter into the invagination in the manner shown in Fig. 30. When invagination to the desired extent has been made, a ligature of strong silk is tied with force, binding the gut to the cone distal to the rubber flange. Both ends of the intestine having been treated in this manner, they are burned, close to the ligatures, down to and through the paper cones (Fig. 31). The invaginated portion of bowel constitutes the bulkhead, the paper cones serving merely to sustain the pressure of the confining ligatures.

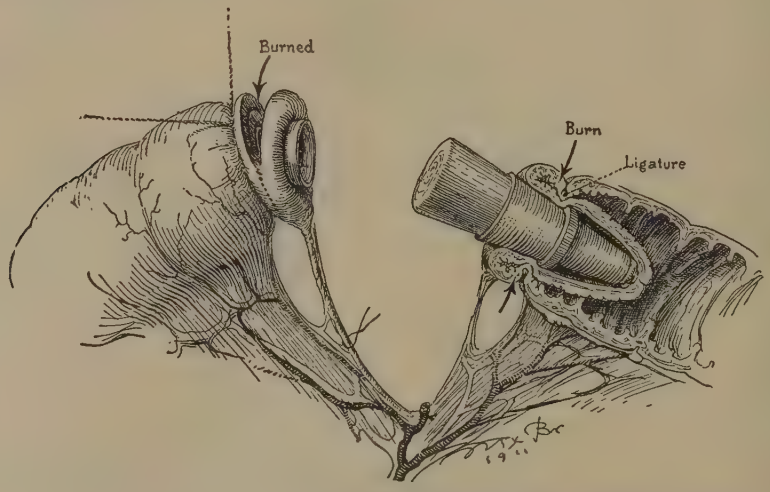


Fig. 31.—On One Side the Gut Has Been Partially Burned Through by the Cautery Knife.

The surgeon has not, until now, concerned himself with the ligation of the mesenteric vessels. The blood supply having been undisturbed is, of course, perfect up to the exact site of the ligature. Precisely at this point the mesentery is transfixed close to the bowel with one of the fine milliner's needles carrying a thread for the circumvection ligature which is to occlude the ultimate little mesenteric vessel. The larger vessels supplying the gut distal to this point are now tied off by circumvection ligatures carried by needles of the kind named. The end-to-end anastomosis is then made[3] with the

[3] Caution. Neither in the act of suturing nor at any time after the final division of the bowel, should one push so hard against the edges of the cones as to dislocate them into the intestinal lumen. Should there be a tendency to this dislocation, it may be obviated by winding a ligature-thread around the cone a few millimetres distal to the rubber flange, room being left between the flange and the thread for the application of the binding ligature.

continuous mattress suture, described by Dr. Hayward W. Cushing and myself, reinforced here and there by an interrupted stitch (Figs. 32 and 33).

Particular attention is called to the possibility of a calamity which even those who are not novices might not always avert unless they exercised especial care to avoid it. I refer to the danger of including in the suture the wall of the invaginated bowel. This error will not occur if the intussuscipiens on each side is slid a little further over its intussusceptum or bulkhead by the fingers of an assistant, as shown in Fig. 33. The stitching being completed, it remains merely to crush the paper cones with the fingers. By this act, the invagination-bulkheads are liberated and the lumen of the bowel is reestablished. I usually push the freed upper cone a foot or two

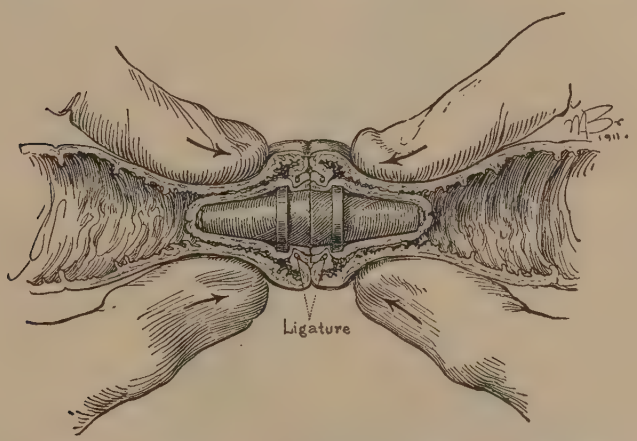


Fig. 32.—The Ends of Intestine and the Paper Cones, Having Been Divided With the Cautery Knife are Apposed, the Invagination Bulkheads Being Held Firmly in Place by the Encircling Ligatures.

centrally along the intestine so that it may be better softened by the time it has descended to the line of suture.

In certain details the method is still imperfect. For example, the size and thickness, and the degree of conicity and of impermeability to fluids of the paper cones best suited to the purpose have not been carefully determined. But in our hands the operation in its present stage of development proceeds without embarrassments. It is, of course, probable that something better suited to the purpose than paper cones will be found.

Advantages of the Method.—1. It is aseptic, except as contamination may occur from stitches which of necessity or by accident have been carried into the lumen of the intestine.

2. The gut may be invaginated to any extent, and even after the binding ligature has been applied, if it should seem desirable to invaginate further,

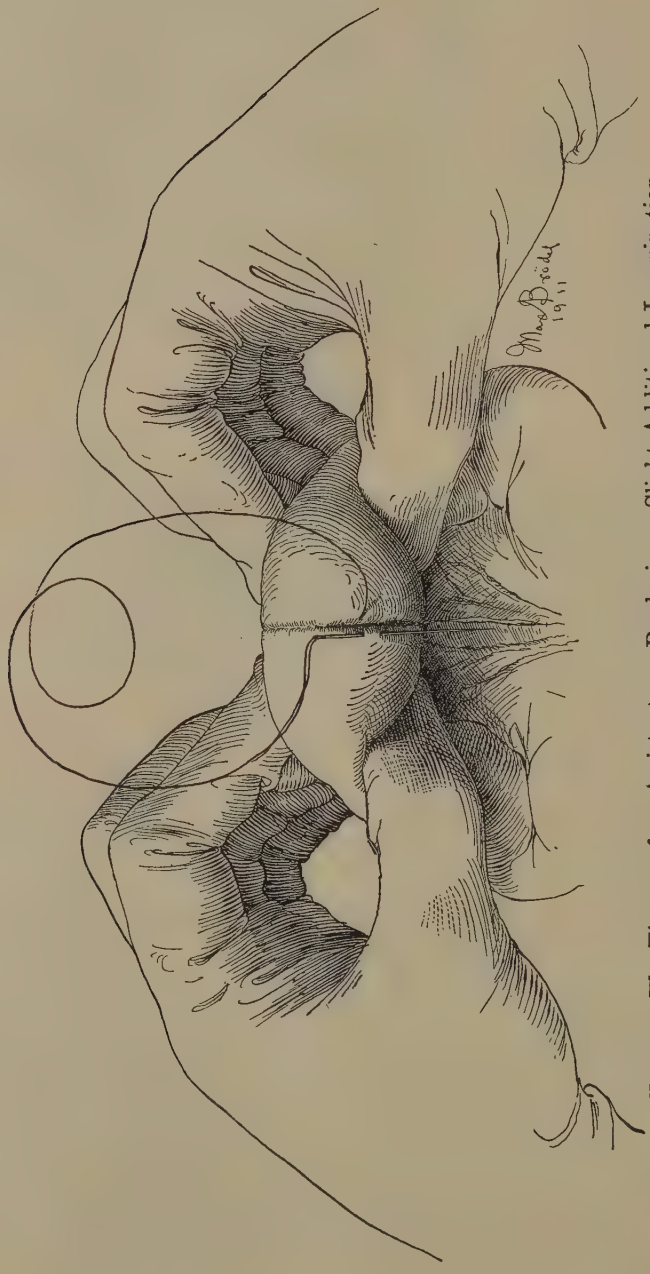


FIG. 33.—The Fingers of an Assistant are Producing a Slight Additional Invagination to Eliminate the Danger of Engaging the Invaginated Bowel in the Suture.

the process may be continued indefinitely, without redivision of the bowel, after merely cutting the ligatures.

3. Precise control of the blood supply.

4. Relief from the annoyance of clamps of any kind, which is particularly to be desired when the operator is working in places difficult of access.

5. The bowel-ends are reduced to the same size, which is desirable for the end-to-end suture.

6. The absolute certainty with which the mesenteric border is turned in.

7. Greater ease of stitch-taking, particularly of the mesenteric border.

8. Its simplicity.

How often have we heard the merits of new methods of intestinal suture extolled almost in the same words!

The working out of the problem has at least been interesting.

This procedure should be practised repeatedly on animals before being undertaken on the human subject.

Most of the experiments were conducted without aseptic precautions, and the dogs were killed on the operating table.

Three were operated upon aseptically, and these were kept under observation for several weeks. All made uninterrupted recoveries, and the intra-abdominal findings at autopsy were ideal.

I have not, for several years, had occasion to make an end-to-end suture of the intestine in the human subject, and am not sure that I should venture, without further experimentation on animals, to employ the bulkhead suture. The procedure is not, as yet, sufficiently perfected to be "marketable," and this is one of my reasons for desiring to publish it in the *Journal of Experimental Medicine* rather than in a periodical devoted to surgery.

AN END-TO-END ANASTOMOSIS OF THE LARGE INTESTINE BY ABUTTING CLOSED ENDS AND PUNCTURING THE DOUBLE DIAPHRAGM WITH AN INSTRUMENT PASSED PER RECTUM[1]

My interest in end-to-end suture (circular enterorrhaphy) of the intestine has had its exuviation periods. The impulse for the current experimental study was given by experiences in the case of a friend upon whom in the course of a very difficult and quite desperately serious operation for uterine and ovarian neoplasms it became necessary to excise a portion of the sigmoid flexure of the colon and to perform within the pelvis an end-to-end suture of this bowel. The operation, according to the testimony of competent observers, was performed in a masterly manner, the competent surgeon having the secure foundation that experimental work in the laboratory alone can give. A faecal fistula through which escaped all of the intestinal contents formed at the line of the circular suture, which presumably broke down more or less completely. For five weeks or more the patient had rigors and high fever, and when her life was almost despaired of the entire picture changed spontaneously within an hour or two and a rapid and uninterrupted convalescence followed. The operator was impressed with the filthiness of the methods of performing end-to-end anastomosis of the colon, particularly in this situation. The immediate incentive for again taking up the subject of intestinal suture was, as I have said, the outcome of weeks of anxious observation of this stormy convalescence.

The allotted time permits only the briefest reference to salient facts in the history of intestinal suture, and I shall confine myself to the consideration of advances which to me seem modern, ancient though they may appear to those of you born years after this hospital was opened.

In the autumn of 1886, in the laboratory of Dr. Welch and with the assistance of Dr. Mall, I undertook the study of intestinal suture. Surely no one ever worked under happier auspices or with more stimulating companions. A few years later Senn was experimenting with his plates of cartilage, and then Abbe with catgut rings. The fact that such contrivances could have been seriously advocated by representative surgeons registers the crudity of intestinal surgery in our country about 30 years ago.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, December 6, 1920.

Johns Hopkins Hosp. Bull., Balt., 1921, xxxii, 98-99. (Reprinted.)

Our experiments were conducted almost daily for about six months. What they yielded is recorded in the papers of Mall and myself. Pertinent to our present study is the fact that the importance of the submucosa was recognized. I have only recently discovered that Gross had mentioned this coat in 1843, but in the intervening years its very existence was altogether overlooked, and every surgeon believed that it was possible to take and advocated the taking of a peritonaeal stitch for the final row. The necessity for including in each stitch at least a part of the submucous coat being now recognized, surgeons have concentrated their attention on the devising of a suture which should be as nearly as possible bacteriologically clean. Numerous instruments and methods designed to lessen the amount of contamination have been contrived but with so little success that the end-to-end suture is quite universally performed today essentially as it was by Czerny in 1878 or by myself in 1886, or by Connell in 1892. The Murphy button (December, 1892) will in my opinion soon be obsolete. The several objections to its use which at the outset were offered have proved valid, and I would add the obvious one, that ideal healing should not be expected to take place on the confines of sphacelated tissues. Nevertheless this ingenious contrivance has enjoyed a marvelous endorsement both in this country and abroad; it tempted incompetent surgeons to essay operations for which they were unequipped, and made appeal to the operator who overestimated the value of time—of the time saved to the patient and lost to himself. Senn in his comprehensive and valuable paper on intestinal suture calls attention to the interesting fact that an Argentine surgeon was awarded a gold medal by the Peruvian Government for his invention of a button which in principle is essentially the same as Murphy's: "A few days ago I received an interesting brochure from Adelbert Ramaugé, professor of surgery in the medical faculty of Buenos Ayres, entitled 'Enteroplexie,' a paper which he read at a meeting of the International Medical Congress of South America, January 20, 1893, and which received the first prize, a gold medal, from the Peruvian government. In this paper I find the description of an instrument which is intended for the same purpose as the Murphy button and which bears a strong resemblance to it."

As the bulkhead suture of Dr. Gatch and myself did not prove to be strictly an aseptic one, I finally abandoned attempts to perform it. But it taught us and Dr. Grey, who simplified it, that a great amount of intestine could safely be turned in—an amount greater than is inverted by the procedure about to be described. The remarkable results obtained by Gatch, with a method which he subsequently developed, deserve wider recognition and furnish convincing confirmation of the above statement in regard to the depth of the flange which may be turned in without fear of causing obstruction.

The current experiments of Dr. Holman and myself, although few, are sufficient in number to have demonstrated the feasibility of the idea, which was to abut and sew together the aseptically closed ends of the intestine and trust to the rapid disintegration of the occluding purse-string of fine catgut for the reestablishment of the bowel's lumen. If advisable, a colostomy would be made proximal to the anastomosis. Dr. Bloodgood tells me that his best results in resection of the large intestine for carcinoma have been obtained in the patients who on admission were so ill that only a colostomy could be ventured, and in those already provided with a preternatural anus; and Dr. J. Shelton Horsley in his paper on "Resection of the Caecum and Ascending Colon" has said enough to indicate an inclination on his part to advocate the use of a protective colostomy. Our procedure is as follows: The muscular coats of the intestine are stripped from the submucosa for about 2 cm. towards the piece to be resected; finely basted, purse-string sutures of catgut are taken in the submucosa, and the bowel divided with a cautery knife between them at the sites of election; then, with the finest point of a Paquelin, the centres of the stumps to be approximated are cautiously burnt; and now the closed, abutted ends of the intestine are united by mattress sutures.

The first five sutures, alternately green and black if one chooses, are used as stays between which, on the stretch, the supplementary ones are taken. Two of the stays are placed very close together, one on each side of the mesenteric attachment; the third is taken at the free border of the gut; the fourth and fifth, one on each side, midway between the two borders. None of the stay sutures is tied until all of these have been placed. Each intervening stitch is tied when made. The nearer the line of suture to the stumps the less, of course, the amount of inturn, but the operator should not let the fear of inverting too much deter him from providing for the apposition of sufficiently broad peritonaeal surfaces. On the other hand, the diaphragms had better not be flappish, although a little slack is permissible.

After the above report was made it occurred to me that one might easily develop a method for puncturing the double intestinal diaphragm from below. A short cylinder of wood containing four housed knives is introduced *per rectum* by an assistant against whose manoeuvres the operating field is of course protected. This cylinder should approximately fill the bowel in order to center the knife perfectly. Inside the gut it is picked up at the brim of the pelvis by the operator and pressed on to the desired point. A second short cylinder, a trailer, threaded on a flexible guide, follows the first, to enable the outside assistant to push the latter to within reach of the operator's hand. The apparatus may be slipped along to any part of the large intestine. Precise details of the apparatus will be given in a subsequent communication.

BLIND-END CIRCULAR SUTURE OF THE INTESTINE, CLOSED ENDS ABUTTED AND THE DOUBLE DIAPHRAGM PUNCTURED WITH A KNIFE INTRODUCED PER RECTUM[1]

The last word on the subject of intestinal suture may some day be written, but surely not until much experimental work has been done with an exactness not hitherto contemplated in investigations of this nature. Authors of text-books and of papers lend their indorsement to some particular variety of suture without offering plausible argument for their preference other than a certain measure of success which has attended its employment in their hands; and faulty methods succeed so well that interest in the relative merits of the details of the various procedures has not been sufficiently aroused to demand greater precision in the experimentation and the critical analysis.

Who knows, for example, how much of the intestinal wall should be turned in; whether two rows of stitching are better than one; whether the suture should be continuous or interrupted; whether the Lembert or mattress stitch is preferable; if the knots should be on the mucous or on the peritonaeal surface; why some stitch-loops (knots outside) fall into the lumen and others remain on the peritonaeal surface; who has considered the factors facilitating or delaying the release of the inturn; and who, indeed, has endeavored to estimate the weight of the burden thrown upon the experimentee to counteract the operator's shortcomings?

Assuredly there is no subject in surgery which has received experimentally a tithe of the labor devoted to intestinal suture. Lives there, indeed, a surgeon who has not made experiments in suturing the intestine—if not on animals, then on man?[2] Such performance on the human subject without rehearsal on animals is a ruthless play with human life, advancing knowledge scarce a tittle.

[1] Ann. Surg., Phila., 1922, xxxvii, 356-364. (Reprinted.)

[2] In our laboratory operative courses for students of The Johns Hopkins Medical School the leading topic from the time of the introduction of these exercises in 1895 up to the present year has been intestinal suture. I embrace this opportunity to express my indebtedness to Harvey Cushing, for thirteen years my brilliant assistant, for his zeal in elaborating these courses and placing them on such a substantial basis that they are now regarded as one of the dominant features of the surgical curriculum for the third-year medical students at The Johns Hopkins University, and are being adopted by other medical schools of this country.

Last winter, at one of the monthly meetings of The Johns Hopkins Hospital Medical Society, Doctor Holman and the writer reported [3] the results of a few experiments having for their object the development of an end-to-end suture more nearly aseptic than had hitherto been devised. The bulkhead suture [4] had taught me that without danger of resulting obstruction, the inturn of intestinal wall (the flange) may be much greater than is generally supposed, so great indeed as quite to fill the lumen of the gut; and the highly instructive and too little known experiments of my former assistant, Dr. Willis D. Gatch,[5] convincingly support this assertion.

In the course of the speculations, which eventually led to the development of the bulkhead suture, I had entertained and discarded the idea of trusting to the absorption of a catgut purse-string to reestablish the intestinal lumen occluded by the double diaphragm of abutted closed ends, and wrote of it as follows (*l. c.*, p. 217): "But a double diaphragm remains to impede for a long time the advance of intestinal contents even if the ligature employed in the tying off of the gut could be relied upon to melt away with the desired promptness." Evidently I did not realize at the time how great the inturn might safely be. Later we ascertained that the amount inverted by the bulkhead method proved to be even greater than in the blind-end suture which it is the purpose of this communication to describe, and produced no obstruction nevertheless.

At the outset of the recent experiments outlined in our report to The Johns Hopkins Hospital Medical Society last winter, I had it in mind to seek a method which at least might be applicable to such cases destined for excision of the large intestine as had previously been provided with a colostomy. Doctor Holman and I found that dogs tolerated quite well what we believed to be a complete obstruction of the descending colon for four days or more, the time apparently required, as a rule, for the disintegration of the catgut (No. 0 doubled) purse-string ligatures with which the abutted blind ends had been closed.[6]

[3] W. S. Halsted and Emile Holman: An End-to-end Anastomosis of the Large Intestine by Abutting Closed Ends and Puncturing the Double Diaphragm with an Instrument Passed Per Rectum. Johns Hopkins Hosp. Bull., 1921, vol. xxxii, p. 98.

[4] W. S. Halsted: A Bulkhead Suture of the Intestine. Jour. Exp. Med., 1912, vol. xv, p. 216.

Ernest G. Grey: Studies on the Aseptic End-to-end Anastomosis of the Intestine. Johns Hopkins Hosp. Bull., 1918, vol. xxix, p. 267.

[5] Willis D. Gatch: Aseptic Intestinal Anastomosis. An Experimental Study. Journ. A. M. A., 1912, vol. lix, p. 185.

[6] Unsterilized or "raw" catgut seemed to dissolve more quickly than the sterilized, but it was not so strong, and Nos. 1 and 0 would frequently break on the tying of the purse-strings.

Soon after making our report it occurred to me to test the feasibility of dividing the purse-string ligatures, or at least of puncturing the double diaphragm by a protected cautery wire, or knife, or knives passed from below—per rectum. The cautery was soon abandoned, being considered dangerous and too complicated. The knives—at first one, later three, and finally four—housed in a short cylinder of wood or metal were tested. I believed in the beginning that the cylinder should approximately fill the bowel in order to centre the knife and thus insure the cutting of the purse-strings, but soon found that these cylinders might actually prevent the centering of the knives unless the stitches were precisely equidistant from the centre.

One knife proved to be better than three or four because (1) less force was required to cut the ligatures or perforate the diaphragms, and (2) one of the three or four knives (blades parallel and both edges of each knife sharpened) might engage the mucosa of the intestinal wall at the margin of or just below the inturn.

The Method.—The vessels supplying the portion to be excised are occluded by fine transfixion ligatures carried by milliner's needles, and are divided as shown in Plate XV, 1. Strong Kocher clamps are applied, one at the distal, the other at the proximal end of the piece deprived of its circulation. Along the proximal edge of the mark made by the proximal clamp, and along the distal edge of the mark of the distal clamp, a finely basted purse-string stitch of silk[1] is run with a milliner's needle; these ligatures are drawn home and only a half knot taken in each; the knots are completed at the moment the intestine has been divided with the electric cautery wire. Prior to the burning, stout threads are tied about the isolated segment at a suitable distance from the basting stitches (Plate XV, 2). The purse-strings can be drawn tighter after the tension caused by the encircling threads has been relieved by the severance of the gut. After the burning, the little overhangs, which may at the discretion of the operator be further sterilized chemically or by the electric wire, are trimmed with scissors as close as feasible to the purse-strings. It is hardly possible to cut these threads in the trimming process, and hence, without fear, one snips the little teat of everted bowel wall completely away (Plate XVII, 1).

For the suturing, a single row of mattress stitches suffices. The first five of these (stay stitches), drawn home and tied, facilitate the introduction of the others and serve as guides to their proper placement. The order in which the stitches have usually been taken is shown in Plate XVII, 2, and Plate XVIII, 1 and 2. The two at the mesenteric border are placed a little closer to each other (Plate XVIII, 1, insert) than the remainder, and are the first to be tied.

[1] Silk was used for the purse-strings to exclude the possibility of misinterpretation of the results. Were the purse-string ligatures of catgut one could not be sure that the restoration of the bowel's patency was due to the cuting of these ligatures and not to their dissolution.

The suturing having been completed, the dog is drawn down until his buttocks overlap the edge of the operating table. An assistant then introduces per rectum the instrument with which the purse-strings are to be cut. Plate XIX, 2 and 3, and Plate XX, 1 and 2, depict the manoeuvres so well that explanatory notes are hardly necessary. The purpose of the short piece of rubber tubing is to protect the sphincter from the sharp edges of the knife and to facilitate its introduction into the rectum. This tube is left in the position shown in Plate XIX, 2, until the knife has been withdrawn.

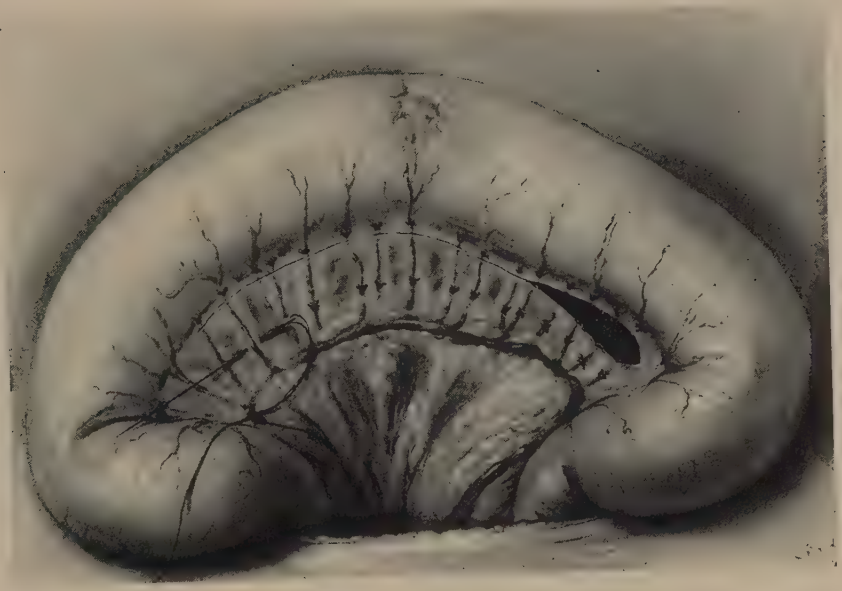
The knife point, protected by a little piece of cork on the tip, is propelled to the required distance by the assistant who manipulates the flexible metal tail (gas tubing) of the instrument. With no more, or rather less, pressure than is required for the introduction of a stomach tube, the knife will glide along the dog's bowel to the ileocaecal valve. When the knife reaches a point in the pelvis easily accessible to the operator's hand it may be guided by him through the remainder of its course to the double diaphragm; but it rarely needs such guidance. The slightest obstacle to the progress of the knife is detected by the assistant in charge of its trailer or tail. The cork having been removed (Plate XX, 1), it is slid down the bowel and out of the way (Plate XX, 2). In making the thrust the operator grasps the metal tubing quite close to the shank of the blade and aims for the centre of the diaphragm, hoping thus to cut both of the purse-strings (Plate XX, 2). Whether these happen to be divided or not would seem, judging by the results, to be immaterial, nevertheless one should make two or three thrusts at slightly different spots, but all as near the centre as possible, in the endeavor to cut these ligatures. The more experienced the operator the better he can sense the greater resistance to the point of the knife offered by the tissues so tightly compressed by the purse-strings. As a precautionary measure a tapered bougie is passed through the diaphragm before closure of the abdominal wound (Plate XX, 3).

Forty-seven dogs have been operated upon by this method without a fatality and without symptoms indicative of an abnormal convalescence. The bowel resected was in every instance the colon. The operations were performed by my former and present assistants and myself, some of them by recent graduates of our school without operative surgical experience. The initial experiments were made with an extemporized instrument—a knife housed in wood and mounted on a brass rod. From the outset, however, it was our intention to have a flexible trailer in case the results with our crude apparatus seemed promising. Notwithstanding the defects of the unwieldy home-made instruments used in the earlier experiments and the lack of experience of several of the operators, not a single death occurred.

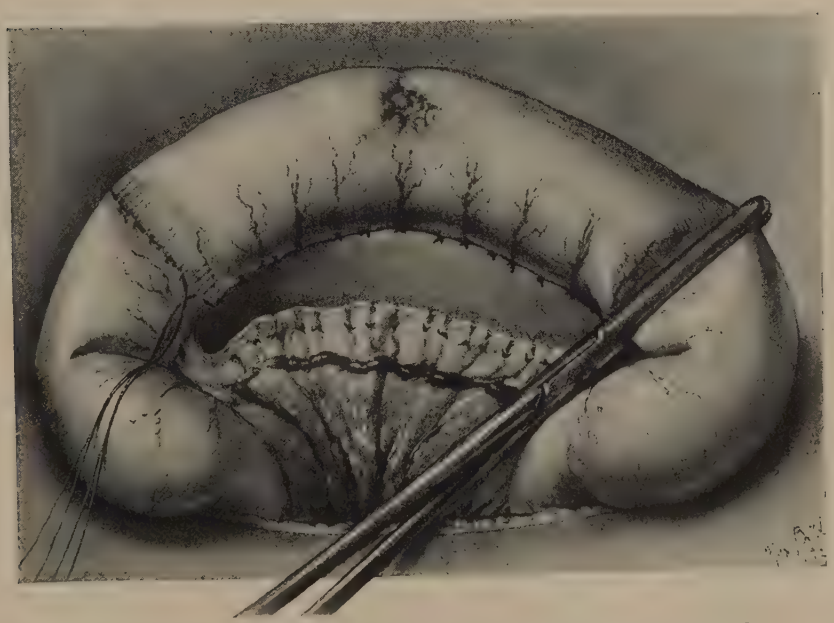
Hardly a year had passed since 1886 when with the assistance of Dr. Franklin P. Mall I made many experiments in intestinal suture,[8] with-

[8] W. S. Halsted: Circular Suture of the Intestine—an Experimental Study. Amer. Jour. Med. Sci., Phila., 1887, n. s. No. 188, p. 436.

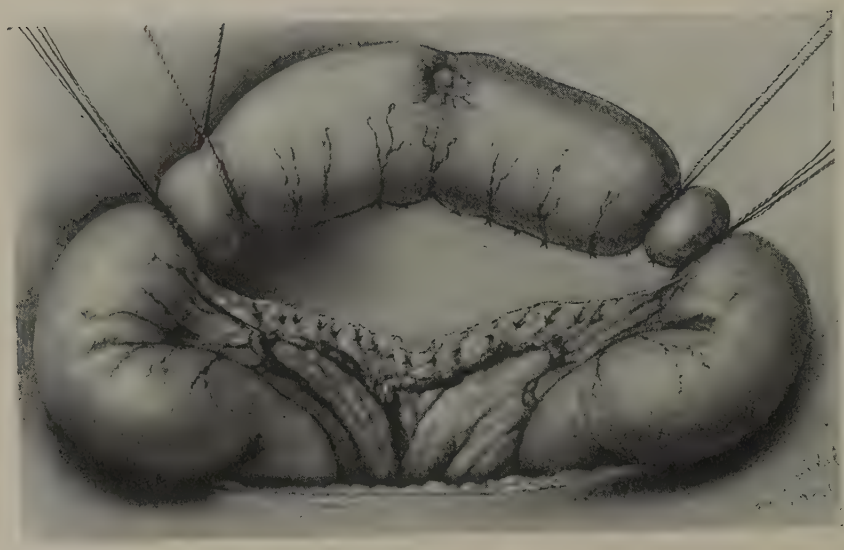
F. P. Mall: Healing of Intestinal Sutures. Johns Hopkins Hospital Reports, Baltimore, 1896, vol. i, p. 76.



1.—Ligation of the Blood-Vessels by Transfixion.

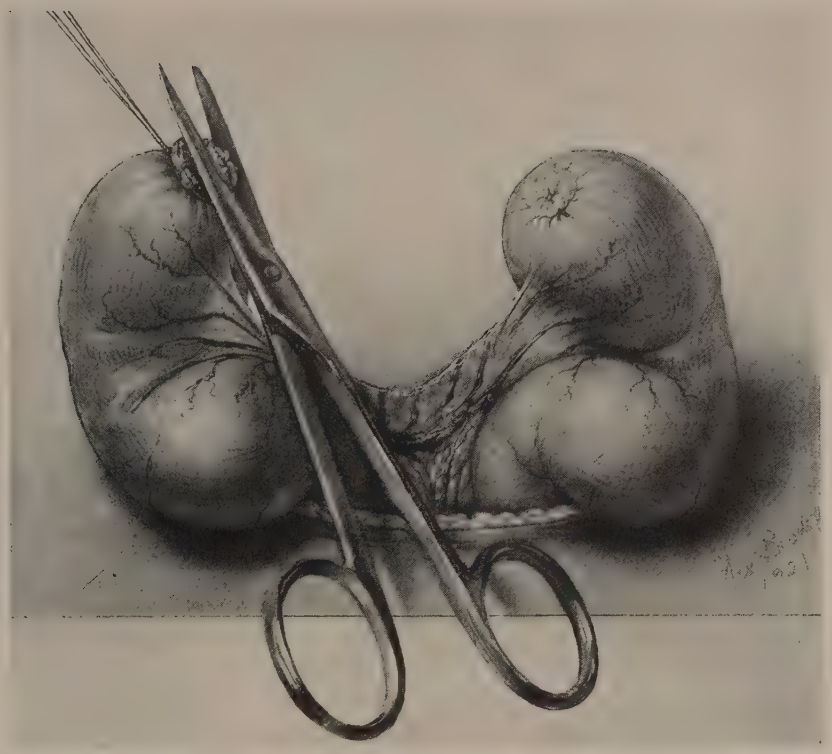


2.—The Marks Made by the Crush of the Clamp Serve Merely to Guide the Placing of the Finely Basted Purse-Strings.

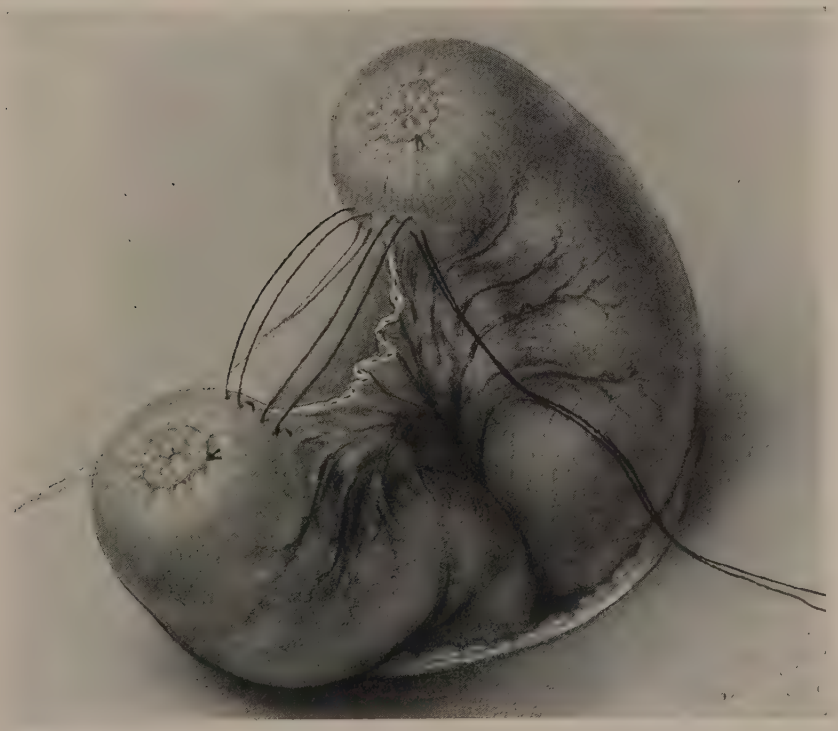


1.—Purse-Strings Tied With Half Knots; Stout Ligatures on the Piece to be Resected.

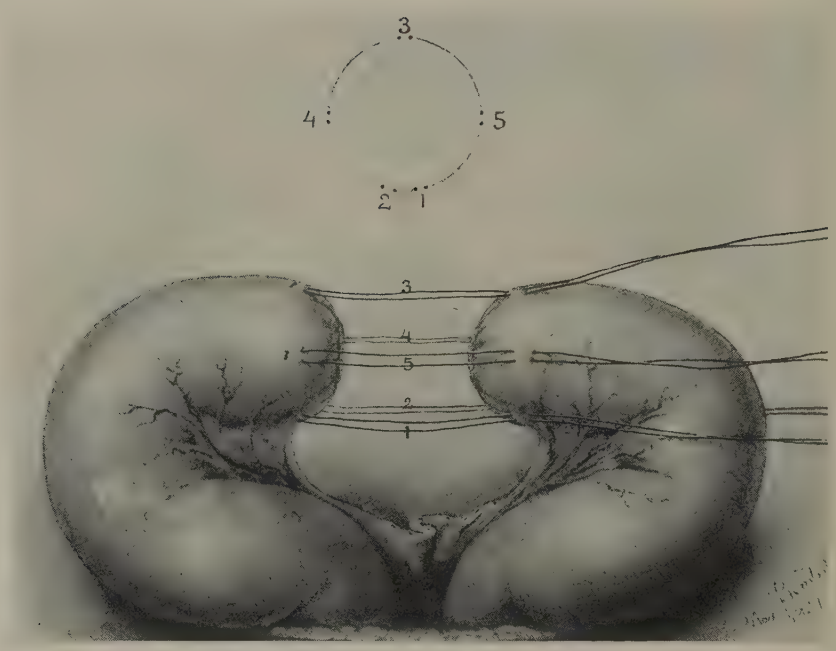
2.—After Division of the Bowel With the Cautery the Purse-Strings Are Tightened and Their Knots Completed.



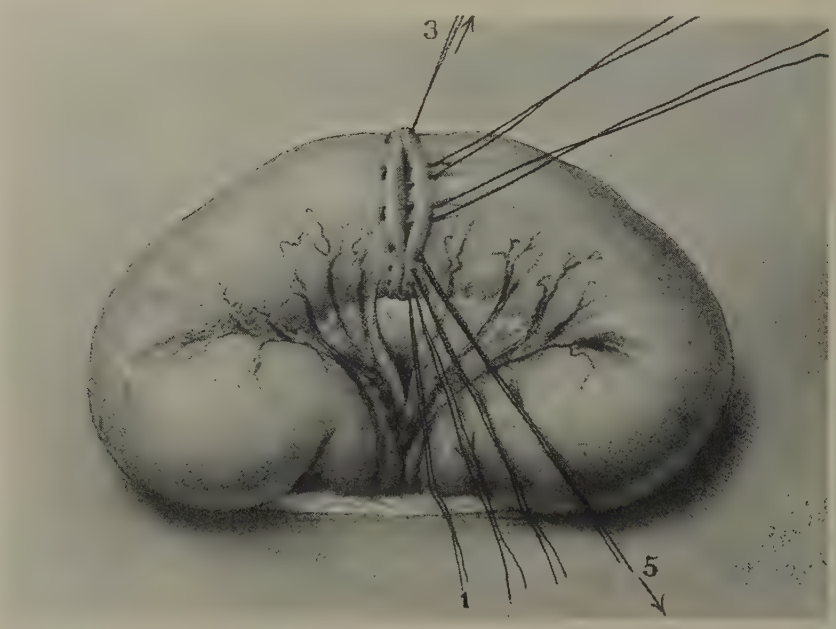
1.—The Overhang May be Trimmed as Close as Possible Without Fear of Cutting the Purse-Strings.



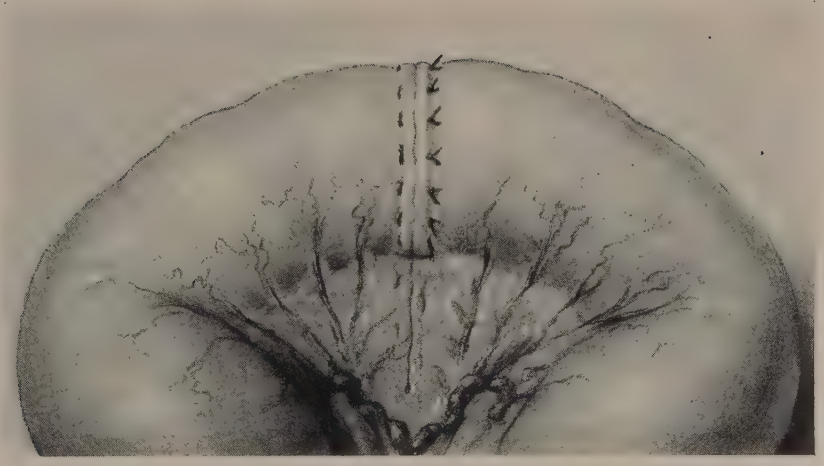
2.—The First of the Mattress Stitches, One on Each Side of the Mesenteric Border.



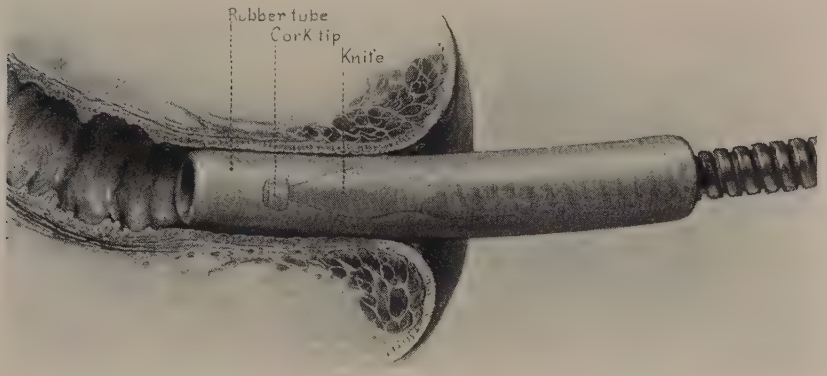
1.—The Five Stay Stitches; the Numerals Indicate the Order in Which They Are Taken.



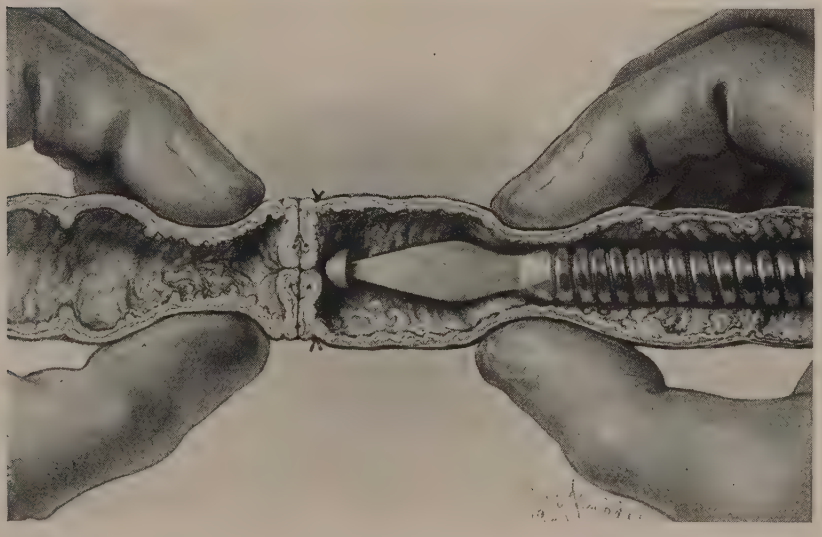
2.—Traction on the Stay Stitches Facilitates the Taking of the Intervening Ones.



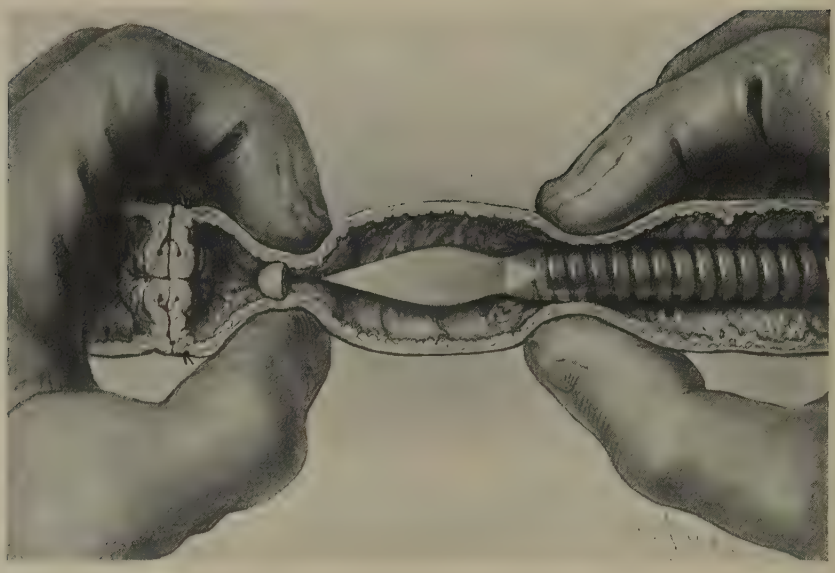
1.—Suture Completed.



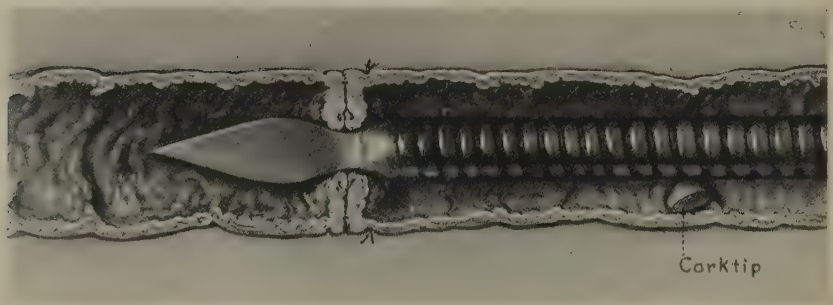
2.—The Knife in Transit Through the Rubber Tube Which Protects The Sphincter.



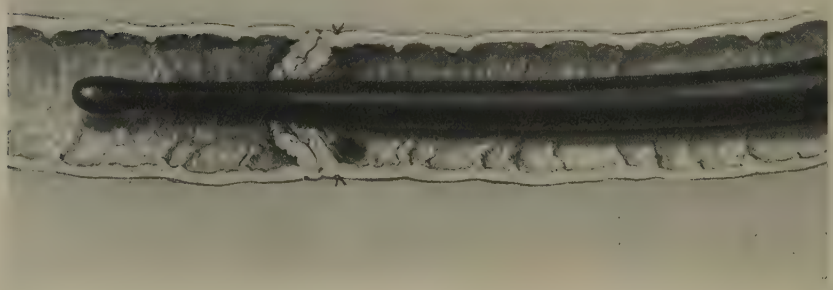
3.—The Knife Has Been Pushed Up to the Diaphragm by the Outside Assistant.



1.—Removal of the Cork.



2.—The Cork Pressed Downwards and the Purse-Strings Divided.



3.—Bougie Passed for Control.

out further experimental investigation of this subject on the part of my assistants and myself. Not one of us (Gatch, Grey, Holman, Halsted) had a series of more than twenty-three dogs without a death. The present series, therefore, of forty-seven consecutive successes being the longest for our laboratory and, so far as I know, hitherto unequalled elsewhere, it would seem worth while to offer it to the profession for trial and criticism.

It will readily be conceded for this method that the amount of soiling could hardly be less; it is little more than occurs in a simple, properly performed appendectomy.

For the first time, therefore, in the history of intestinal suture two of the factors, the soiling and the amount of inturn, have been reduced almost to a constant, and hence we are now better prepared to test on animals the relative merits of the various stitches in common use.

In operations on the human intestine the surgeon's only criterion has been the mortality; for one cannot explore the abdomen of his patient every few hours after operation in order to determine the amount of reaction (infection and adhesions) about the line of suture, the fate of the stitches, the depth of the inturn, the delay in its unfolding, etc.

Unembarrassed by soiling, or eversion of the mucous membrane, or the presence of a single clamp or other instrument, or by the fear that the mesenteric border may be imperfectly inverted, or that the amount turned in may be too great or too little, or that some point of a running stitch may have been too loose or too tight, the operator proceeds in orderly and uniform manner from the beginning to the end of the performance.

In addition to the two constant factors mentioned above—the amount of soiling and the amount turned in—it is possible, at least in experiments upon the dog, to have another constant factor, viz., the depth to which the stitches penetrate. One may learn in a few minutes to sense the submucosa with the point of the needle and to include a part of it in the stitch without entering the lumen of the gut. With a little practice one learns not only to pick up a thread of the submucosa but to press the needle along in the plane of this coat. The resistance in the latter case may be so great as to remind one of that experienced in the taking of subcuticular stitches. Members of our upper surgical staff can all testify to the accuracy of this statement. And who will not assent to the view that it is desirable to take the submucous stitch when this is feasible? Experience has taught us that stitches which do not enter the mucous coat become ultimately subperitonaeal loops, and long before the diaphragm or flange has unfolded. Uninfected, they are cast outwards, and not discharged into the bowel's lumen; whereas, the perforating stitches seem usually to ulcerate their way into the gut. We sometimes find one or more of these perforating stitches hanging in or near the

line of suture even when the unfolding process is about complete—when little trace of the diaphragm remains. In the track of all of these stitches which are discharged into the bowel there has necessarily been an infected sinus from the moment of their placement until their release. Dr. Florence Sabin,[9] in her elaborate and unique study of the healing of Doctor Holman's end-to-end anastomoses of the intestine, rarely found that a stitch had perforated; when this had occurred in ever so slight degree there was inflammatory reaction, sometimes a small abscess, about the silk thread.

Sutures falling into the lumen of the bowel, being quickly transported, are lost; only such are discoverable as happen still to be attached to the intestinal wall when the animal is sacrificed. Those discarded on the peritonaeal surface may remain for several years and be distinctly seen shimmering under an endothelial film. The more perfect the operation the fewer the adhesions, and frequently one finds every one of the loops outside if the mattress stitches have been happily made. Undoubtedly in the hands of novices most of the stitches penetrate the mucosa; nevertheless many of these perforating mattress stitches cut their way outwards; when they have pulled through the mucosa, the fistulous tract becomes sealed from within and the suture's passage towards the peritonaeum may thereafter be a clean one.

The slogan "knots inside" naturally makes an appeal, for it seems universally to be taken for granted that the threads necessarily work their way into the lumen. Year after year for thirty-five years I have had opportunities to convince myself of the fact that in the cases which heal most ideally the stitches come to the peritonaeal surface. The omental adhesions to the line of suture in such cases are very light (occasionally they are absent) and in a few weeks, in a few days even, may be absorbed and have left no trace.

Consulting the original paper of Lembert,[10] I was interested to find that his stitches were cast off into the bowel. He states this definitely and makes no mention of having ever seen at autopsy a loop of thread shimmering under the peritonaeum. This fact of itself suffices to prove that his stitches, contrary to the universal belief, were perforating ones. But we do not require this particular proof, for he distinctly states that he intentionally entered the lumen of the intestine with his needle, except when the wall was thick;

[9] Florence R. Sabin: Healing of End-to-end Intestinal Anastomoses with Special Reference to the Regeneration of Blood-Vessels. Johns Hopkins Hosp. Bull., 1920, vol. xxxi, p. 289.

[10] A. Lembert: Mémoire sur l'entéroraphie, avec la description d'un procédé nouveau pour pratiquer cette opération chirurgicale. Répertoire gén. d'anat. et de physiologie pathologiques, etc. Paris, 1826, vol. ii, p. 100.

and in this event the needle *glided*[11] between the coats. Now it is questionable, I think, that even in the thick-walled cases he slid the needle between the coats without entering the intestinal lumen. He apparently knew nothing of the existence of the submucosa, and his needle, if it "glided," must have passed on one side or the other of this coat—either between the muscular and submucous coats, or between the latter and the mucosa; it would not *glide* along *in* the tough submucous coat. If the stitches had included only the peritonaeal and muscular coats they would have split the longitudinal fibres, have constricted or crushed the circular ones and at best have had an insecure hold; and if they had perforated the submucosa they undoubtedly entered the intestine's lumen. Thus, in all probability, Lembert's stitches quite invariably entered the lumen, whatever the thickness of the bowel's wall; and, in any event, Lembert intentionally perforated the wall unless it was thick. Hence the Lembert stitch has been universally misunderstood, and the erroneous description of some early author has been passed on from one writer to another until the present time. Picture the amount of soiling there must have been in Lembert's experiments. In placing his stitches he introduced a finger into the bowel, using it as a guide, as a darning ball.[12] Furthermore, the stitches perforated the intestinal wall and were discharged into the lumen. Nevertheless the five dogs upon whom he operated all recovered.

In the entire literature of intestinal suture there are, perhaps, no more impressive examples of nature's ability to protect against man's faulty operative methods than those furnished by Merrem's[13] resections of the pylorus (1809 and 1810).

Merrem excised the pylorus in three dogs—two in 1809 and one in 1810. In the first dog, attempts at invagination being unsuccessful, the raw edges of the stomach and duodenum were apposed and held by only three stitches.

[11] A. Lembert, *l. c.*, p. 105: "L'aiguille pénètre à 2 lignes environ du bord saignant droit, dans la cavité de l'intestin, ou bien sa pointe glisse entre les tuniques musculeuse et muqueuse, suivant que l'intestin est plus ou moins épais."

[12] Lembert, *l. c.*, p. 106: "Le chirurgien, . . . porte l'index de la main gauche dans la cavité de l'intestin, de manière à soutenir les bords saignans avec la pulpe de ce doigt."

[13] Merrem's paper (Animadversiones quædam chirurgicæ experimentis in animalibus factis illustratæ. Giessæ, 1810) is listed in the Index Catalogue of the Surgeon General's Library, but could not be located. Therefore I wrote to Professor Payr, who, unable to find it in Leipzig, kindly sent me Carl Langenbeck's abstract (Abschrift eines Referates von C. J. M. Langenbeck, Professor der Anatomie und Chirurgie, Direktor des chirurgischen Spitals in Göttingen, aus Bibliothek für die Chirurgie, 4. Band 1. Stück. Göttingen. Rudolph Deuerlich, 1811). I appealed also to Prof. Felix Landois, of Berlin, who found Merrem's paper and sent me quotations from it which he had graciously translated into German.

Death occurred on the twenty-third day from "inanition"; there was no peritonitis, and the suture-line was so well healed that no trace of it remained.

In the second and third dogs the stomach was invaginated into the duodenum—serosa apposed to mucosa. The second dog recovered; the third died. In all of the experiments the threads of the gastro-enterorrhaphy were brought out of the abdominal wound and fastened to the surface with adhesive plaster. The severed pyloric artery could not be tied on account of its depth; the haemorrhage was checked with sponge and spirits.

Let those of us who are inclined to be content with our present methods of end-to-end anastomosis bear in mind these experiments of Merrem and of many other early research workers and observe on animals the early stages of repair of our own intestinal sutures, to the end that we may understand the part that nature plays to protect the patient from the crudity of our handiwork.

Notwithstanding much experimentation, we have been unable to improve upon the method developed thirty-five years ago,[14] unless perhaps the procedure submitted in this communication shall prove to be an advance. We have at least learned in recent years that it is safe, and probably advisable, to make a deeper inturn, and have devised a cleaner procedure. It remains to be determined whether in the blind-end method the continuous suture will yield results as good as those we have obtained by the mattress stitches. Better they can hardly be.

For lateral anastomosis the mattress stitches possess the advantage that they can all be taken before the bowel is opened, that one row of them suffices, and that infection of one stitch is unlikely to be conveyed to the others.

As stated earlier in the paper, it is not known how deep the inturn should be. It may safely be assumed, however, that the deeper the inturn the better, provided obstruction is not produced by it. Granting this, how many rows of suture should be made? Fortunately the apposed serous surfaces of the diaphragm tend to remain firmly in contact. That the process of unfolding begins promptly we know from the rapid cutting outwards of the properly placed sutures as well as from early observations on the mucous side; and from this continuous effort to unfold we infer the force maintaining the peritonaeal surfaces in contact from the line of suture to the raw edges. Every stitch, whether essential or superfluous, interferes more or less with the circulation, hence the necessity for eliminating any that may be unnecessary. In circular suture of the intestines of a variety other than the

[14] W. S. Halsted: Circular Suture of the Intestine—an Experimental Study. Amer. Jour. Med. Sci., Philadelphia, 1887, n. s., vol. xciv, p. 436.

blind-end we have advocated (1887, *loc. cit.*) a few presection stitches, taken chiefly with the purpose of preventing the outward rolling of the bowel wall and thus facilitating the introduction of the mattress row.

If we bear in mind that every perforating stitch is a source of danger, however slight, as well as a menace to the circulation, our efforts will be directed towards the suppression of unnecessary stitches and the cultivation of the sense which makes possible the appreciation with the needle's point of the resistance offered by the submucosa. That in resection of the human colon one row of mattress stitches is better than two, I am not as yet prepared to affirm, but in the dog it has given results in the blind-end suture so perfect that I should regard a second row as a factor of danger rather than security.

The more perfect the execution of any method of end-to-end anastomosis, the less reaction about the line of suture and the greater the rapidity of the unfolding of the inturn, of the complete restoration of the lumen of the bowel. In one of our specimens, for example, little remained of the diaphragm on the tenth day; in another there was no trace of it on the seventeenth day. On the other hand, the inturn in one case was about as deep on the 109th day as at the beginning. An exceptionally bad result in this case (an early one) was predicted because the force required to puncture the diaphragms with the three broad knives was so great that the stitches (perforating ones) tore little streaks in the bowel walls. The operation was cleverly performed by an eminent European surgeon who had not practised the submucous stitch. The animal's recovery and normal convalescence were surprising; at no time in the 109 days after operation were there symptoms of obstruction. It will readily be understood that great reaction, causing matting of the omentum and intestines about the line of suture, may lead to the formation of fibrous tissue in the infiltrated intestinal wall so dense and so extensive as to delay for a long time, and possibly permanently prevent the complete unfolding of the inturn. The surgeon should bear in mind this fact, unemphasized perhaps hitherto, and the experimenter in testing the relative merits of the various procedures for lateral as well as end-to-end anastomosis should note the rapidity of the unfolding and accept the tardy disappearance of the flange as evidence of a faulty technic either of method or execution or both.

The opportunity has not as yet presented at The Johns Hopkins Hospital to perform the blind-end suture on the human subject. We shall probably test it first on cases in which a lateral anastomosis is not feasible. The knife passes readily to the ileocaecal valve in the dog, and in one instance Doctor Holman, after resecting the caecum, abutted the closed ends of ileum and ascending colon and cut the diaphragms with the knife; the dog re-

covered normally. When the splenic flexure is hooked high (Payr's Doppelflinte) it might be difficult without mobilizing to traverse it with the knife. But for resections of the descending colon, of the sigmoid flexure, of the rectum when the sphincter is to be preserved, and possibly of the gastric end of the oesophagus, the method deserves, I believe, a trial.

I am greatly indebted to Dr. F. L. Reichert and to Dr. Emile Holman for assistance in every phase of the work. Dr. Mont Reid also has most kindly aided me in many ways. A detailed report of the experiments will be made later by Doctor Reichert and Doctor Holman.

THE OPERATIVE TREATMENT OF INGUINAL HERNIA

THE RADICAL CURE OF HERNIA[1]

Dr. William S. Halsted presented five patients[2] upon whom he had performed his operation for the cure of inguinal hernia. He described the operation as follows:

1. The incision begins at the external abdominal ring, and ends one inch or less (less than one inch in children) to the inner side of the anterior superior spine of the ilium on an imaginary line connecting the anterior superior spines of the ilia. Throughout the entire length of the incision everything superficial to the peritonaeum is cut through.

2. The vas deferens, with its vessels, is carefully isolated up to the outer termination of the incision, and held aside.

3. The sac is opened and dissected from the tissues which envelop it.

4. The abdominal cavity is closed by quilted sutures passed through the peritonaeum at a level higher by 1½-2 inches than that of the so-called neck of the sac.

5. The vas deferens and its vessels are transplanted to the upper outer angle of the wound.

6. Interrupted, strong silk sutures, passed so as to include everything between the skin and the peritonaeum, are used to close the deeper portion of the wound, which is sewed from the crest of the pubes to the upper outer angle of the incision. The cord now lies superficial to these sutures, and emerges through the abdominal muscles about one inch to the inner side of the anterior superior spine of the ilium.

7. The skin is united over the cord by interrupted stitches of very fine silk. These stitches do not penetrate the skin, and when tied they become buried. They are taken from the under side of the skin, and made to include only its deep layers—the layers which are not occupied by sebaceous follicles.

Dr. Halsted has for more than two years sewed most of his wounds in this way. The method was suggested to him from his experiments on dogs. He thinks that it is very difficult, and perhaps impossible, to disinfect the skin of a dog, and believes that pyogenic organisms may occasionally be present in the sebaceous follicles of the skin. At any rate, he had repeatedly observed

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, November 4, 1889.

Johns Hopkins Hosp. Bull., Balt., 1890, i, 12-13.

[2] First operations for hernia, *W. S. H.*

pus in the suture holes of the perforating skin stitches, and could not with any certainty secure primary union of the skin wounds of dogs until he had resorted to this subcutaneous method of sewing the skin.

Dr. Halsted remarked in this connection that whether or not it were possible or easy to disinfect absolutely the human skin, he had been much impressed with the fact that skin sutures not infrequently suppurate, even in wounds sewed by the most careful surgeons in this country and abroad. He thought it advisable, therefore, to test for a time the subcutaneous, buried, skin suture.

8. One or two small, short gauze plugs are used as wound drains.

The After Treatment.—The gauze plugs are removed at the first subsequent dressing—usually at about the seventh day. The patients are allowed to walk about on the 21st day.

The following is a brief summary of the cases:[3]

Case 1.—Wm. H. Richardson, colored, age 8 years. Operation, June 13, 1889, for the cure of large congenital inguinal hernia on the right side. The sac when opened contained caecum and vermiform appendix—a very short mesocaecum bound the sac to its contents.

June 2d.—The wound has healed by first intention, except where the gauze plug was introduced. Linear cicatrix.

July 4th.—Patient is allowed to get up and walk about.

Case 2.—George Holdorf, German, blacksmith, age 20. Operation, June 17, 1889, for the cure of a moderately large, reducible, right inguinal hernia.

June 18th.—Gauze plug removed.

June 25th.—Patient is discharged for misdemeanor. Wound has healed by first intention. Linear cicatrix.

Case 3.—John Bleecher, German, blacksmith, age 48. Operation, August 16, 1889, for the cure of a large, reducible, right inguinal hernia. The neck of the sac was large enough to admit the tips of four fingers.

August 26th.—Passes urine through wound. Infer that one of the deep sutures was passed through the wall of the bladder.

September 4th.—Patient passes all of his urine through the penis.

September 17th.—Patient is out of bed. The wound is healed except at its lower angle.

Case 4.—Joseph Davis, age 8 years. Operation, October 9, 1889, for the cure of a small, reducible, left inguinal hernia.

October 19th.—Wound has healed by first intention. Linear cicatrix.

November 3d.—Boy is allowed to get up and walk about.

Case 5.—Frank Fisher, age 7 years. Operation, October 12th, for the cure of a small, right inguinal hernia.

October 20th.—Wound has healed by first intention. Linear cicatrix.

November 4th.—Boy is allowed to get up and walk about.

THE RADICAL CURE OF HERNIA[1]

The patient is one who was operated upon three weeks ago for the radical cure of an inguinal hernia. The celloidin dressing was removed as usual on the third day and the wound was as usual perfectly healed. The scar, you will observe, is scarcely perceptible. The patient is exhibited because he has a complication—thrombosis of the femoral vein. We take such deep stitches into the pillars of the ring that I am not surprised at this complication. In one case we passed a stitch through the wall of the bladder. The patient, however, recovered.

Thus far there has been no return of the hernia in any of the twelve or more patients operated upon by the method which I described to you last year. The muscles of the abdominal wall are divided out to the level of the anterior superior spine of the ilium. The walls of the sac are sutured by quilted sutures at as high a level as possible. There is, of course, no neck to the sac after the abdominal muscles have been divided. The sac is cut away and the vas deferens, with its vessels, is transplanted to the outer angle of the wound. The divided muscles and the pillars of the ring are stitched with very deep quilted sutures. It is sometimes necessary to take as many as eight or even ten of these sutures. The skin wound is closed by buried skin sutures. A small, narrow pad of sterilized gauze, placed over the line of the incision, is held in place by two or three turns of a gauze bandage which has been soaked in absolute alcohol. Celloidin is then poured liberally over the little dressing.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, October 20, 1890.

Johns Hopkins Hosp. Bull., Balt., 1890, i, 111-112.

EXCISION OF SOME OF THE VEINS OF THE CORD IN THE OPERATION FOR THE RADICAL CURE OF INGUINAL HERNIA[1]

Dr. Halsted presented several cases to illustrate a modification of his operation for the cure of hernia. The bundle of veins which accompanies the vas deferens is often as large as one's finger. He believes that some or most of these veins may be superfluous, and, accordingly, excises all but one or two of them. By this procedure the cord may often be reduced to less than one-fourth of its original size. It is reasonable to suppose that the size of the cord may influence the tendency of the hernia to return.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, January 18, 1892.

Johns Hopkins Hosp. Bull., Balt., 1892, iii, 76.

THE RADICAL CURE OF INGUINAL HERNIA IN THE MALE[1]

Shuh said, "If no other field were offered to the surgeon for his activity than herniotomy, it would be worth while to become a surgeon and to devote an entire life to this service." Quite as well, certainly, might this be said of operations for the radical cure of hernia. There is, perhaps, no operation which has had so much of vital interest to both physician and surgeon as herniotomy, and there is no operation which, by the profession at large, would be more appreciated than a perfectly safe and sure cure for rupture.

Just now, most of the so-called radical-cure operations are under a cloud. They have not withstood the test of time. Modern textbooks of surgery refer to operations for the radical cure of hernia with more or less misgiving. The newest American surgery[2] disapproves of operations for the radical cure of reducible hernia if a truss can be worn, and believes that Czerny's method is as good as any, should an operation be necessary.

The most telling blows against radical-cure operations in this country have been dealt, perhaps, by Bull. His papers on the radical cure of hernia and on relapses after the various operations for the radical cure of hernia have produced a profound impression on both practitioners of medicine and practitioners of surgery. Bull concludes the first of these papers[3] as follows: "These observations will, without doubt, be duplicated in the cases yet to be traced, and go to strengthen the conviction that all methods of radical cure will be found unsatisfactory." In his second paper[4] he writes: "I hold, after the knowledge of these failures and in view of the well-established fact that after the old operations for hernia recurrence has been often long delayed, that it is wise to drop the term *cure* and to estimate the value of given procedures by the relative proportion of relapses."

From 1883 to 1885, Bull operated for the cure of hernia chiefly by what he calls Socin's method—ligature and excision of the sac. From 1885 to

[1] Read at the Annual Meeting of the Medico-Chirurgical Faculty of Maryland, Easton, Maryland, November 17, 1892.

Johns Hopkins Hosp. Bull., Balt., 1893, iv, 17-24. (Reprinted.)

Also: Ann. Surg., Phila., 1893, xvii, 542-556.

[2] An American Textbook of Surgery. Keen and White.

[3] Bull: On the radical cure of hernia, with results of one hundred and thirty-four operations: Medical News, 1890.

[4] Bull: Notes on cases of hernia which have relapsed after various operations for radical cure.

1889 he employed what he calls Banks' method—ligature and excision of the sac, with suture of the pillars of the external ring. Since 1889 he has practised the sewing up of the canal after ligating and excising the sac.

Of the cases operated upon by the first method, at least 27.27 per cent relapsed within one year; of those operated upon by the second method, at least 40 per cent relapsed within one year; and of those operated upon by the third method, at least 42 per cent relapsed within one year.

"My own results," writes Bull, "as to relapse being no better by the complicated method of suture of the ring alone, or of the ring and canal, than by the simpler method of excision of the sac after ligature, I shall confine myself to that method of operation till other procedures which have stood the test of years make a more promising showing." Bull's results became less promising the longer he observed his cases. From a series of one hundred and thirty-six cases there remained only four which had been over four years without recurrence. In his second paper Bull says: "Now that ten years have elapsed since the modern radical operations have been in vogue, we ought to hear of, or have presented to us, patients who have been more than five years, at the least, without relapse. We could naturally expect to see such cases occasionally at a special hospital. But there are none such." Notwithstanding these facts, Bull does not advise that operations for the relief of hernia be discontinued, nor does he wish to discontinue efforts to discover more satisfactory methods for its cure. For, of the cases operated upon, almost all were relieved for a time, and some for several years; and of the cases which had relapsed, the majority were more comfortable than they had been before they were operated upon.

These are admirable papers and faithfully depict what is to be expected if a hernia is operated upon by the methods which Bull has employed. Today, therefore, the majority of surgeons operate for the radical cure of hernia only when the hernia is strangulated or cannot be retained with a truss. A few believe that they have had results good enough to justify their operations upon almost every case which presents itself.

Until the sixteenth century incarcerated hernia was treated only by taxis. If taxis failed, the patient died. An ordinary rupture and stone cutter, Pierre Franco, was the first to relieve incarceration by herniotomy. As preeminent among his fellows as Paré was among surgeons, he is one of the most illustrious figures in surgical history. He has described, and probably was the first to conceive both the intraperitonaeal and extraperitonaeal methods of herniotomy. The following is an extract from his chapter on herniotomy:[5]

[5] Lehrbuch der Chirurgie, Bd. iii. Eduard Albert.

"When all other means have failed we proceed to operate. One must have a little staff of the thickness of a goose-quill, or somewhat thicker, and round, on one side flat and half round and it must be rounded off at the front end that one may press forward easier. One makes accordingly an incision at the upper part of the scrotum, drawing towards the pubes, and at the outset makes the opening only just large enough to admit the staff, for one must take care that he does not thrust into the intestines. When one has found the hernial sac, one must insinuate the little staff between it and the groin and then push upwards. The flat side of the staff must be up. It would not succeed if the staff were entirely round for the knife would then glide from side to side. When one has pushed the staff far enough, he cuts upon the flat side of it through the flesh of the scrotum and groin so as not to injure the intestines now that he has made a larger opening; there is no danger in making the opening large enough to enable one to replace the intestines the more easily because the sac and the flesh of the belly can then be the more readily stretched, and hence perhaps the intestines be returned the more nearly into their correct position. One must reintroduce them little by little. Should the case occur that they will not go back easily and without great pressure because of too great an accumulation of their contents or on account of inflammation, then one must proceed as follows: one takes the hernial sac and cuts it very delicately upon the nail while one raises the sac with hooks and cuts it through to the intestines; and when one has made an opening large enough to admit the staff one pushes it very gently upwards between the sac and the intestines; at the same time one must push the parts aside so as to see if he is catching the intestines. The intestines, however, are not easily caught because they are homogeneous and smooth. One must accordingly divide the sac upon the staff up to the peritonaeum, that is, up to the highest point, namely, to the hole where the intestines begin to descend to the scrotum; but one must make a generous opening into the peritonaeum without fear and for the sake of greater safety, just as one does in desperate cases of the kind. One then takes a little piece of fine linen and pushes the intestines gradually back, beginning with those which are higher up towards the peritonaeum and which lie nearer to the belly."

The suggestion of Franco to replace the intestines with linen is an excellent one, and for me one of the proofs of his genius. There are today many surgeons who have not discovered this device and who labor with the fingers to introduce the slippery intestines. With a piece of gauze one can replace the intestines rapidly and with precision, whereas the manipulation of the intestines with the fingers is often a ludicrous performance. Paré, about the middle of the sixteenth century, gives precise instructions for performing herniotomy. He was probably the first surgeon to prescribe herniotomy for all cases of incarcerated hernia. But it was not until the end of the seventeenth century or beginning of the eighteenth century that the operation, through the efforts of Wiseman, Petit, and Richter, became generally recognized and practised.

From a clinical, anatomical and pathological standpoint the work of Sir Astley Cooper on hernia is undoubtedly the greatest of all, and very little has been added to our knowledge of hernia of all kinds since his book appeared. From his chapter on the operation for inguinal hernia one gets a good idea of the respect which surgeons at the beginning of this century had for arteries. Speaking, for example, of the division of the little external pubic artery, which always crosses the sac near the external abdominal ring, he says:

"This circumstance, however, is in no degree alarming to a surgeon who expects it, as the bleeding may be stopped by the vessel being compressed by an assistant, or if the artery is larger than usual, owing to the scrotum being long distended by the disease, the blood may be stopped by a ligature."

Cooper substituted his world-famed herniotome for the bulb-pointed knife, and abolished the use of the hollow director which the disciples of Franco and Paré believed to be indispensable.

Otherwise the technique of herniotomy is today precisely that of Franco, the gifted stone and rupture cutter of the sixteenth century, except that in preaseptic times he, perhaps wisely, preferred the extraperitonaeal[6] to the intraperitonaeal method. The actual war which these two methods stirred up among surgeons for more than a century is interesting. On the side of Petit, who after Franco was the great disseminator and defender of the method, we find arrayed from the English, Cooper, Key, Teale, Paget, Liston, Gay, Lawrence, and others; from the Germans, Roser, Shuh, Dummericher, Busch, Baum, and others; from the French, Gosselieu, Chauvet, Le Dentu, and others.

The same objections and the same refutations appear year after year. The inconsistency of those opposed to the extraperitonaeal method is remarkable. They were, for example, all of them advocates of the taxis, and would not resort to the cutting operation until the taxis had failed; but objected to the extraperitonaeal herniotomy because of the danger of returning unseen the contents of the sac. Richter is the only one to whom it occurred pointedly to inquire why that should be feared at the time of the operation which had not been feared a quarter of an hour earlier when taxis was being performed.

Dieffenbach, the most conspicuous advocate of the intraperitonaeal method for inguinal and femoral hernias, permits the extraperitonaeal method for umbilical and ventral hernias, because "it lessens the danger of peritonitis."

From Celsus we have reports of operations for the cure of reducible hernias. At that time it was believed that many hernias were accompanied by a

[6] Kocher, by the way, has recently devised an extraperitonaeal operation for the radical cure of hernia. (Correspondenzblatt für Schweizer Aerzte, 1892.)

rent in the peritonaeum. The incision was made down to the hernial contents, and the supposed rent in the abdominal wall was closed by sutures.

Heliodorus gives a most masterly description of an operation for the radical cure of hernia which would be a creditable performance today. The directions which he gives for cutting off the sac are unique, and as follows:[7]

"We must cut off the hernial sac with great care, for if we take away less than is protruded, the result will be the production of a new hernia, for the edges of the wound will be slack and the way prepared for the slipping out again of the intestines. If one resects more than is protruded by drawing out additional peritonaeum from its legitimate resting-place, then the hernia will recur, for the edges of the peritonaeum, because of the too great resection, cannot be brought together, and the patient is in danger because normal parts have been taken away. In order, therefore, that we may not miss excising an amount which is precisely correct it is necessary to draw the sac outwards by catching the tip of the same; so soon as the edges of the abdominal wound begin to be everted, enough of the peritonaeum has been drawn out and so much is to be excised. If the edges of the abdominal wound have been strongly everted, then one must assume that more peritonaeum has been drawn out than is necessary and should pull with less force. When just enough peritonaeum has been drawn out the sac is to be twisted. Having been cut off along a straight line, the peritonaeum becomes folded upon itself and screwed up and closed so tight that not even the point of a probe can be introduced."

That Heliodorus recognized the existence of the infundibuliform fascia there can be no doubt,[8] for he says that one has not reached the true hernial sac until the last of the layers which enclose together the hernial tumor and the spermatic cord has been divided. With the exception of the torsion of the sac, which we replace with the suture, the operation for the radical cure of hernia in the time of the Roman emperors was quite on a par with the operation as it is usually performed in our day. Four hundred years later the operation had ceased to exist.

I am not inclined to attach much importance to the manner of closing the sac, nor to the level at which it is cut off, nor to the treatment of the sac in general, provided the peritonaeum is not allowed to protrude outwards into the wound. With the revival of the operation for the radical cure the testicle was sacrificed. Paul of Aegina directs that the sac be ligated at two places, and that, cutting between the ligatures, the testicle and sac be removed. The Arabians did not advance beyond this method. At length when it occurred to Lanfrancous to attempt to cure hernia without sacrificing the testicle, he believed that the inspiration was from God. In 1882 and 1883 Kraske advised castration in certain difficult cases for the cure of hernia.

[7] Lehrbuch der Chirurgie, Bd. iii. Eduard Albert.
[8] Albert, *loc. cit.*

Guido von Cauliaco, although not sacrificing the testicle himself, was inclined to excuse others for doing so, because the hernia was less likely to return after the testicle had been removed, and the generating power was not lost. This observation of Guido von Cauliaco is interesting because it implies that in the Middle Ages the cord must have been regarded as the important factor in the production of hernia. From that time to the introduction of antiseptic surgery, methods of all sorts, many of them cruel and some barbarous, have been in vogue. They may be classified as follows:

1. Pressure with or without the simultaneous application of irritating and so-called contracting remedies.
2. Caustics and the actual cautery.
3. Ligature of the sac, with or without cutting it off.
4. Introduction of foreign bodies into the hernial sac.
5. Healing in of a detached portion of skin, or of a portion of impacted skin into the abdominal ring.
6. The injection of irritating fluids within or outside of the hernial sac.
7. The subcutaneous suture.

Some of these methods are interesting as curiosities, and others because they are still practised.

The employment of the actual cautery for the cure of hernia appealed particularly to the knife-dreading Arabian school.[9] After the rupture had been returned and the cord drawn aside, the cautery was applied over the external abdominal ring and kept there until it had burnt through the skin and hernial sac down to the bone. The region of the external abdominal ring having been described by Paul of Aegina as triangular, three different cautery points were sometimes used for this operation—a straight one for the center point, a gamma-shaped one for the sides, and a lens-shaped one for the surface of the triangle. The celebrated filium aureum or punctum aureum, the golden ligature or the golden puncture, was introduced by Geraldus in Metz. The sac was laid bare and then occluded by a golden thread so passed as not to include the spermatic cord.

Wood's subcutaneous suture is still practised in Great Britain, and, according to Bassini, has for years been the favorite method in Italy. I can remember when in New York the honors were about equally divided between Wood's method and Heaton's injection method. So late as 1882, J. H. Warren, of Boston, wrote a book in behalf of his injection method, which is essentially the same as Heaton's. The injection of alcohol (Schwalbe) is quite popular in Germany and France.

With the introduction of antiseptic surgery, or rather several years after Lister's first contributions to this subject, Annandale, Steele, Riesel, Nuss-

[9] Albert, *loc. cit.*

baum, and a few others, made bolder attempts to cure ruptures. Although differing from each other in detail, the methods of these surgeons were essentially alike and are embraced under the following heading: Ligature of the exposed neck of the sac, with extirpation or incision of the sac.

We are indebted to antiseptic surgery for reintroducing to us the operation of Heliodorus.

In 1878, Czerny, in his valuable Beiträge zur Chirurgie, records seven cases in which after ligating the neck of the sac and excising the sac he had sutured the pillars of the external abdominal ring. He attributes to Richter the conception of the operation, saying that it was believed by Richter that for the radical cure of hernia not only must the hernial sac be destroyed but also must the ring be narrowed. He courteously concedes also to Billroth, to whom his Beiträge are dedicated, credit for the idea because Billroth had said, "If we could artificially produce tissues of the density and toughness of fascia and tendon, the secret of the radical cure of hernia would be discovered." Some years later, Banks published what he supposed to be a new operation for the radical cure of hernia. Although practically the same as Czerny's, it was for several years known as Banks' operation in this country and in Great Britain.

I am surprised to see that Lauenstein, so recently as 1890, accredits Banks with Czerny's operation. Lauenstein's ideas of Czerny's operation were perhaps obtained from the latter's first publication, and not from his Beiträge zur Chirurgie; for in his Beiträge zur Chirurgie Czerny regrets that he did not remove the sac in his earlier operations. That Banks uses silver wire instead of silk or catgut in sewing together the pillars of the external abdominal ring, and that he possibly cuts off the sac at a higher level than Czerny does, hardly entitles him to the operation. The use in general of powerful sewing materials in surgery is, it seems to me, based on a misapprehension in pathology. If, for example, the tension is so great that wire must be used to bring parts together, one must not expect permanent assistance from the wire; for the tissues will eventually be cut through by the stitches to the extent necessary to relieve the tension.

Czerny had not observed his cases long enough to undeceive him as to the value of his operation, and he expresses himself very cautiously as to its ultimate results. He sets an excellent example for less conscientious surgeons when, agreeing with Schede, he does not propose to operate upon controllable ruptures until the experience of many years with ruptures which cannot be controlled by a truss shall have convinced him of the safety and reliability of his method.

In 1879, Tilanus of Amsterdam collected for the International Medical Congress data from one hundred and twenty-two cases which had been oper-

ated upon by what were supposed to be antiseptic methods. Of the ultimate results not enough had been ascertained to enable one to form conclusions. The mortality was 6 per cent, or too great to justify operating upon ruptures which could be comfortably retained by a truss.

The most important contributions since Czerny's to the radical cure of hernia are from McEwen, McBurney, Bassini, Kocher, and Lucas-Championnière. In his own hands, McEwen's operation seems to have been perfect. It is difficult to say upon just what part of the operation its success depends. I am not inclined to ascribe it to the tampon, although Lauenstein testifies that he was fortunate enough to see the anatomical preparation from a patient cured by McEwen's method who for years subsequent to the operation had done heavy work without a truss. The patient died of an aortic aneurism. His inguinal canal was firmly closed, and on the abdominal side of the same and firmly adherent was the sac folded up into a dense cushion, which strengthened the abdominal wall in this situation. Unlikely as this may seem, we must unhesitatingly accept the testimony of such men as Lauenstein and McEwen. Bassini, on the other hand, had an opportunity to observe at an autopsy ninety-five days after the operation, that the tampon which he had made somewhat after the manner of McEwen's had been completely absorbed; not a trace of it remained. One is so familiar with the fate of redundant tissues that it is hard to convince oneself that the tampon remains for years just as it was at the operation, and that even if not entirely absorbed it is not at least greatly reduced in size. The tampon being in place, the first step of McEwen's operation is concluded. The second step is to restore the valve-like form of the inguinal canal. This is done by one or more mattress sutures which unite the conjoined tendon to the aponeurosis of the oblique muscle. The application of these sutures is simple, although from the description it would seem to be complicated.

How much McEwen's wonderfully good results might be attributed to the wearing of trusses would depend upon the percentage of truss wearers. It is strange that so little success has attended the practice of McEwen's operation in this country. Is the fault with the operator or with McEwen's description of the operation? Whatever the future of this operation may be, McEwen certainly took an advance step in the treatment of inguinal hernia.

McBurney's operation is undoubtedly so well known to all Americans that a description of it would be superfluous. It would seem to be the most heroic test which is possible of scar tissue and open-wound treatment. But scar tissue, however thick and dense, is not the tissue best calculated to recover from the effects of blows, or to permanently withstand the constant pressure of the abdominal contents. McBurney has kindly informed me by

letter that although the hernia has recurred in some of his cases, the percentage of recurrence is so small that he still practises his method. Bull tabulates several relapses after McBurney's operation. More than three years ago I described a new operation for the cure of inguinal hernia in the male.[10] Six or eight months later, Bassini of Padua published his operation for the cure of inguinal hernia which he had performed two hundred and fifty-one times, with only seven returns and no deaths except one, and that from pneumonia after the wound had healed. Bassini's operation and mine are so nearly identical that I might quote his results in support of my operation.

Instead of trying to repair the old canal and the internal abdominal ring, as McEwen had tried to do, I make a new canal and a new ring. The new ring should fit the cord as snugly as possible, and the cord should be as small as possible. The skin incision extends from a point about 5 cm. above and external to the internal abdominal ring to the spine of the pubes. The subcutaneous tissues are divided so as to expose clearly the aponeurosis of the external oblique muscle and the external abdominal ring. The aponeurosis of the external oblique muscle, the internal oblique and transversalis muscles and the transversalis fascia are cut through from the external abdominal ring to a point about 2 cm. above and external to the internal abdominal ring. The vas deferens and the blood vessels of the cord are isolated. All but one or two of the veins of the cord are excised. The sac is carefully isolated and opened and its contents replaced. A piece of gauze is usually employed to replace and retain the intestines. With the division of the abdominal muscles and the transversalis fascia the so-called neck of the sac vanishes. There is no longer a constriction of the sac. The communication between the sac and the abdominal cavity is sometimes large enough to admit one's hand. The sac having been completely isolated and its contents replaced, the peritonaeal cavity is closed by a few fine silk mattress sutures, sometimes by a continuous suture. The sac is cut away close to the sutures. The cord in its reduced form is raised on a hook out of the wound to facilitate the introduction of the six or eight deep mattress sutures, which pass through the aponeurosis of the external oblique and through the internal oblique and transversalis muscles and transversalis fascia on the one side, and through the transversalis fascia and Poupart's ligament and fibres of the aponeurosis of the external oblique muscle on the other.

The two outermost of these deep mattress sutures pass through muscular tissues and the same tissues on both sides of the wound. They are the most important stitches, for the transplanted cord passes out between them. If

[10] Bulletin of The Johns Hopkins Hospital, Vol. I, No. 1; Johns Hopkins Hospital Reports, Vol. II, surgical fasciculus, No. I.

placed too close together, the circulation of the cord might be imperiled, and if too far apart, the hernia might recur. They should, however, be near enough to each other to grip the cord. The precise point out to which the cord is transplanted depends upon the condition of the muscles at the internal abdominal ring. If in this situation they are thick and firm, and present broad raw surfaces, the cord may be brought out here. But if the muscles are attenuated at this point, and present thin cut edges, the cord is transplanted farther out. The skin wound is brought together by buried skin sutures of very fine silk.[11] The transplanted cord lies on the aponeurosis of the external oblique muscle and is covered by skin only. In both of the patients presented you will feel the cord in this situation distinctly. They were operated upon two and three and one-half years ago.

Bassini believes that he restores the inguinal canal to its physiological condition, inasmuch as he makes "a canal with two openings, an abdominal and a subcutaneous; furthermore with two walls, a posterior and an anterior, through the middle of which the spermatic cord passes obliquely." But the original canal is not by any means an affair so simple as Bassini's. To reproduce the equivalent, anatomically and physiologically, of the inguinal canal is impossible. Bassini's operation, although essentially the same as my operation, is different in some respects. 1. Bassini always brings the cord through the muscles at the internal abdominal ring. The point out to which I transplant the cord is determined, as I have said, by the condition of the muscles. 2. Bassini does not excise the superfluous veins. I believe that it is advisable to reduce the size of the cord as much as is practicable. 3. In Bassini's operation the cord lies posterior to the aponeurosis of the external oblique muscle; in mine, between this aponeurosis and the skin. To secure for the cord the position which Bassini recommends an additional row of stitches is required. Unless it should be demonstrated by a comparison of the results of the two methods that there is something to be gained by these additional stitches, it would be well for the sake of the wound and the operator to discard them.

Kocher thinks that the methods of Bassini and himself are to be preferred to other methods, McEwen's for example, because they (the former) enable the patient to get out of bed on the eighth day. I fail to see anything in the methods of Kocher and Bassini and myself which might enable the patient to get out of bed earlier than if he had been operated upon by the method of McEwen. The time to be spent in bed depends upon the judgment of the surgeon and not, open methods excluded, upon the particular

[11] Instead of the interrupted buried skin suture as shown in Plate VIII, we now use an uninterrupted buried skin suture without knots, which is withdrawn after two or three weeks.

method. Our patients are kept upon their backs for 21 days. Wounds thoroughly healed throughout per primam are not strong in eight days. One can easily tear open a typically healed wound which is not more than six or seven days old. Not long ago in attempting to restore a club foot to its proper position I accidentally and with very little force pressed wide open a wound which had healed in the typical way and was eight days old.

A wound is certainly stronger on the fourteenth day than it is on the seventh, and stronger on the twenty-first day than on the fourteenth. Just how long wounds of skin and muscle which have healed by first intention may continue to increase in strength we do not know. In our hernia wounds, the subcutaneous ridge of aponeurosis and muscle which results when the parts have been brought together properly by buried mattress stitches does not disappear entirely for five or six or more weeks. I sometimes question the propriety of allowing, as I do, my patients to walk about on the twenty-first day.

The technique of operations for the radical cure of hernia should be unusually perfect, because we have to violate occasionally what I consider to be one of the most important principles of antiseptic surgery. We have to constrict the tissues somewhat with our deep sutures. It is not always possible to bring together the pillars of the external abdominal ring without a little tension. One can of course make relaxation cuts, but these would be quite as undesirable as a moderate amount of tension. Our hernia wounds illustrate admirably the danger of constricting tissues. We never resort to drainage of any kind for fresh wounds. And with the exception now and then of a hernia wound, none [12] of our fresh wounds suppurate. Inasmuch as we rarely if ever have occasion to constrict tissues in other fresh wounds, it is almost certain that the occasional stitch abscess in a hernia wound is due to tissue constriction plus, of course, the infection. To provide for a good circulation in every particle of tissue in and immediately about a wound is as much a part of our technique as are the ordinary antiseptic precautions. The better the circulation the less the likelihood of suppuration.[13]

Since the opening of The Johns Hopkins Hospital, 3½ years ago, 82 operations for the radical cure of hernia have been performed, and without

[12] Not more than one or two in a year. *Vid.* Johns Hopkins Hospital Reports, Vol. 2, surgical fasciculus, No. 1.

[13] I have performed three amputations within a year and a half through tissues which were almost surely infected and with instruments and hands which were as surely infected. No attempt was made to disinfect the wounds except that they were washed with a sterilized salt solution, and in one instance with warm water from the faucet. Great care was exercised in ligating and sewing and dressing to avoid constricting the tissues and to provide against tension. The wounds were closed as usual. They all healed absolutely by first intention.

a death. Sixty-four of the cases were males, 18 were females. Of the females, four had femoral, 13 inguinal and one umbilical hernia. Of the males, 63 had inguinal and one femoral hernia. Five of the males were operated upon by Dr. Brockway by McBurney's method. Of these five cases two have recurred; two have not been heard from; and one, a boy 2½ years old, is still well, 20 months after the operation. The cord in so young a patient is so very small that the hernia might be cured for several years by almost any method.

My operation, with or without modification, was employed in 58 cases. Of the cases which healed per primam, not one has recurred. The wounds which suppurated were immediately laid wide open and allowed to heal by granulation. For the result in such cases the open method, and not mine, is responsible. There have been six recurrences—Nos. 2, 12, 24, 27, 39, 52. No. 2 took cathartics and got out of bed a few days after the operation. He was discharged for insubordination on the eighth day, before his wound was firm. In No. 12 the cord was not transplanted. In No. 24 a stitch abscess formed several weeks after his discharge. There is a slight impulse, on coughing, at the site of the abscess. In No. 27 the wound suppurated. The stitches were removed and the wound was laid wide open and allowed to heal by granulation. This patient had a diffuse suppurative inflammation of the neck at the time of the operation. No. 39, the wound was opened for haemorrhage and allowed to heal by granulation. No. 52, the wound suppurated, was laid open, and healed by granulation. The patient has a flabby abdominal wall. The scar has stretched throughout its entire length, and there is an impulse all along the scar on coughing.

Statistics of Operations at The Johns Hopkins Hospital for the Radical Cure of Hernia[14]

1. W. H. R., aet. 8. Large, right, congenital, inguino-scrotal, reducible hernia. Operation, 13, 6, 1889. Healed per primam. Last observation, 1, 6, 1891, the result is still perfect, 2 years after the operation.

2. G. H., aet. 20. Large, right, oblique, inguino-scrotal, reducible hernia. Operation, 17, 6, 1889. Healed per primam. Discharged for insubordination, 24, 6, 1889. Patient got out of bed several times and took cathartic pills without permission. 14, 6, 1892, there is a complete return of the hernia.

3. J. B., aet. 48. Very large, right, oblique, inguino-scrotal, reducible hernia. Operation, 16, 8, 1889. The bladder was caught in one of the stitches, and the wound, consequently, was laid open and allowed to heal by granulation. Last observation, 10, 3, 1892, the hernia has not returned, 2½ years after the operation.

[14] A few cases have been added to this list since the reading of the paper.

4. M. E. L., aet. 14. Small, right, oblique, inguinal, reducible hernia. McBurney's operation, 19, 8, 1889. Last observation, 21, 3, 1892, the hernia has not returned, 2½ years after the operation.

5. J. D., aet. 8. Small, left, oblique, inguinal, reducible hernia. Operation 9, 10, 1889. Healed per primam. Last observation, 5, 3, 1892, result still perfect, 2 years and 5 months after the operation.

6. C. I. B., aet. 38. Small, left, femoral, reducible hernia. Operation, 11, 10, 1889. Healed per primam. Discharged, 4, 11, 1889.

7. F. F., aet. 7. Small, right, congenital, inguinal, reducible hernia. Operation, 12, 10, 1889. Healed per primam. Last observation, 25, 3, 1892, result still perfect, 2 years 5 months after the operation.

8. J. W. F., aet. 12. Left, oblique, inguinal, reducible hernia. Operation, 21, 12, 1889. Healed per primam. Last observation, 30, 1, 1890, result still perfect. 1, 3, 1892, patient cannot be found.

9. S. McN., aet. 46. Large, right, femoral, strangulated hernia. Operation, 31, 12, 1890. Discharged, 2, 2, 1891. Result unknown.

10. L. L., aet. 27. Small, right, oblique, inguinal, reducible hernia. Operation, 14, 2, 1890. Open wound. 21, 3, 1892, the hernia has not returned.

11. H. S., aet. 37. Large, right, inguinal, reducible hernia. Operation, 21, 2, 1890. Healed per primam. Last observation, 1, 12, 1892, linear scar, result still perfect, nearly three years after the operation.

12. G. G., aet. 28. Large, left, oblique, inguino-scrotal, irreducible hernia. Operation, 2, 5, 1890. Cord not transplanted. Healed per primam. 14, 10, 1890, the hernia has recurred.

13. J. H., aet. 39. Small, left, direct, inguinal, reducible hernia. Operation, 20, 5, 1889. Healed per primam. Last observation, 21, 6, 1890, the hernia has not recurred.

14. E. H., aet. 35. Small, left, femoral, strangulated hernia. Operation, 17, 5, 1890. Discharged, 22, 6, 1890. Result unknown.

15. E. P., aet. 45. Small, right, oblique, inguinal, reducible hernia. Operation, 29, 5, 1890. Healed per primam. Last observation, 16, 6, 1890, the hernia has not recurred.

16. H. B., aet. 8. Small, right, inguinal, reducible hernia. McBurney's operation, 17, 7, 1890. Not heard from since discharged, 23, 8, 1890.

17. H. D., aet. 2½. Right, inguino-scrotal, congenital, reducible hernia. McBurney's operation, 17, 7, 1890. Last observation, 1, 3, 1892, the hernia has not recurred.

18. A. E., aet. 5. Small, right, oblique, inguinal, reducible hernia. McBurney's operation, 23, 7, 1890. 24, 11, 1890, the hernia has recurred.

19. G. W., aet. 45. Small, right, oblique, inguinal, reducible hernia. McBurney's operation, 23, 5, 1890. Not heard from since discharged, 8, 9, 1890.

20. K. F., aet. 11. Small, right, oblique, inguinal, reducible hernia. McBurney's operation, 4, 8, 1890. Last observation, 27, 3, 1892, the hernia has not recurred.

21. E. W., aet. 5. Small, left, oblique, inguinal, reducible hernia. McBurney's operation, 11, 8, 1890. 11, 11, 1890, the hernia has recurred. Patient wears truss.

22. D. H., aet. 9. Small, left, oblique, inguinal, reducible hernia. Operation, 23, 8, 1890. Healed per primam. Last observation, 23, 3, 1892, linear scar, result still perfect.

23. T. Y., aet. 52. Large, right, oblique, inguinal, irreducible hernia. Operation, 17, 9, 1890. The adhesions were too firm and too extensive to admit of the reduction of the hernia.

24. J. C. H., aet. 27. Large, left, oblique, inguinal, reducible hernia. Operation, 24, 9, 1890. Healed per primam. Last observation, 15, 11, 1892. A few weeks after the patient had left the hospital a small abscess formed about one of the stitches. Just at this spot there is a distinct impulse on coughing.

25. G. S., aet. 49. Large, left, oblique, inguino-scrotal, irreducible hernia. Operation, 27, 9, 1890. The operation was a difficult one and consumed two hours. Stitch abscess, 1, 3, 1892. Patient cannot be found.

26. C. M., aet. 4. Large, right, inguinal, congenital, reducible hernia. Operation, 7, 10, 1890. Healed per primam. 1, 3, 1892, patient cannot be found.

27. M. C., aet. 20. Large, right, oblique, inguino-scrotal, reducible hernia. Operation, 26, 11, 1890. Healed per primam. The wound had been healed nearly three weeks when an abscess formed about the outermost stitch. This might be accounted for by the fact that the patient had at the time an acute purulent inflammation of the neck. Last observation, 5, 6, 1892, the hernia is beginning to recur.

28. W. McS., aet. 3. Large, right, oblique, inguinal, strangulated hernia. Operation, 10, 11, 1890. Healed per primam. Last observation, 25, 3, 1892, firm linear scar, result still perfect.

29. E. L. P., aet. 7. Small, right, oblique, inguinal, reducible hernia. Operation, 21, 11, 1890. Healed per primam, except for a small stitch abscess. Last observation, 20, 3, 1892, linear scar, perfect result.

30. A. M., aet. 15. Left, oblique, inguinal, reducible hernia. Operation, 24, 11, 1890. Healed per primam. Last observation, 28, 3, 1892, linear scar, perfect result.

31. S. P., aet. 30. Small, right, direct, inguinal, reducible hernia. Operation, 29, 1, 1891. Healed per primam. Last observation, 2, 4, 1892, linear scar, perfect result.

32. F. H., aet. 40. Small, right, oblique, inguinal, reducible hernia. Operation, 28, 1, 1890. Healed per primam. Last observation, 30, 3, 1891, linear scar, perfect result.

33. J. W., aet. 28. Small, right, oblique, inguinal, reducible hernia. Operation, 23, 1, 1891. Healed per primam. 1, 6, 1892, cannot be found.

34. F. S., aet. 27. Small, left, oblique, inguinal, reducible hernia. Operation, 6, 2, 1891. Healed per primam, except for minute stitch abscess. Last observation, 2, 3, 1891, linear scar.

35. J. L., aet. 14. Small, left, oblique, inguinal, reducible hernia. Operation, 20, 2, 1891. Wound suppurated. Last observation, 1, 3, 1892, hernia has not recurred.

36. J. T., aet. 47. Small, right, oblique, inguinal, reducible hernia. Operation, 24, 2, 1891. Healed per primam. Last observation, 15, 11, 1892, linear scar, perfect result.

37. P. J., aet. 6. Small, left, oblique, inguinal, reducible hernia. Operation, 17, 3, 1891. Healed per primam. Last observation, 14, 4, 1891, result still perfect.

38. E. K., aet. 27. Small, left, direct, inguinal, reducible hernia. Operation, 13, 3, 1891, open wound. Last observation, 21, 3, 1892, the hernia has not recurred.

39. E. J. C., aet. 23. Small, right, oblique, inguinal, irreducible hernia. Operation, 5, 6, 1891, the wound was opened completely for haemorrhage. Healed by granulation. 2, 4, 1892, the hernia has recurred.

40. M. P., aet. 35. Left, oblique, inguinal, reducible hernia. Operation, 8, 5, 1891. Stitch abscess. 1, 6, 1892, patient cannot be found.

41. F. S., aet. 14 months. Small, right, inguino-scrotal, congenital, reducible hernia. Operation, 19, 5, 1891. Healed per primam. 1, 6, 1892, patient canot be found.

42. J. K., aet. 4. Right, oblique, inguino-scrotal, reducible hernia. Operation, 26, 6, 1891. Wound suppurated. Last observation, 5, 4, 1892, the hernia has not recurred.

43. F. D., aet. 49. Small, right, oblique, inguinal, reducible hernia. Operation, 26, 6, 1891. Stitch abscess. Last observation, 3, 4, 1892, the hernia has not recurred.

44. P. H., aet. 5. Left, oblique, inguinal, irreducible hernia. Operation, 11, 9, 1891. 2, 10, 1891, stitch abscess. 1, 3, 1892, patient cannot be found.

45. P. C., aet. 28. Small, right, direct, inguinal, reducible hernia. Operation, 16, 7, 1891. Wound healed per primam. 23, 3, 1892, patient cannot be found.

46. W. G. W., aet. 2½. Small, right, inguino-scrotal, congenital, reducible hernia. Operation, 25, 7, 1891. Wound healed per primam. Last observation, 1, 4, 1892, linear scar, perfect result.

47. G. B., aet. 22. Right, oblique, inguino-scrotal, reducible hernia. Operation, 4, 8, 1891. Wound healed per primam. Last observation, 1, 7, 1892, linear scar, perfect result.

48. A. McI., aet. 26. Right, oblique, inguino-scrotal, strangulation hernia. Operation, 8, 9, 1891. Wound suppurated. Last observation, 1, 3, 1892, the hernia has not recurred.

49. M. W., aet. 11. Right, inguino-scrotal, congenital, reducible hernia. Operation, 27, 8, 1891. Wound healed per primam. Last observation, 1, 11, 1891, the hernia has not recurred.

50. G. B., aet. 3. Small, right, oblique, inguinal, reducible hernia. Operation, 30, 9, 1891. Wound healed per primam. Ultimate result unknown.

51. J. W. B., aet. 5. Small, left, oblique, inguinal, reducible hernia. Operation, 9, 10, 1891. Stitch abscess. Last observation, 3, 3, 1892, the hernia has not recurred.

52. H. P., aet. 29. Small, right, oblique, inguinal, irreducible hernia. Operation, 9, 10, 1891. Wound suppurated. Healed by granulation. Last observation, 20, 3, 1892, the scar has stretched throughout its entire length. Truss advised.

53. E. L. B., aet. 28. Small, right, oblique, inguinal, reducible hernia. Operation, 3, 12, 1891. Wound healed per primam. Last observation, 7, 4, 1892, linear scar, perfect result.

54. A. M., aet. 4. Small, right, oblique, inguinal, strangulated hernia. Operation, 25, 11, 1891. Stitch abscess. Last observation, 6, 4, 1892, the hernia has not recurred.

55. H. B., aet. 21. Small, left, oblique, inguinal, reducible hernia. Operation, 10, 12, 1891. Stitch abscess. 1, 6, 1892, patient cannot be found.

56. H. R., aet. 20. Small, right, oblique, inguinal, irreducible hernia. Patient's hernia has been once unsuccessfully operated upon by another surgeon. Operation, 8, 1, 1892. Wound healed per primam. Last observation, 3, 1, 1893, linear scar, perfect result.

57. H. H., aet. 2. Small, right, oblique, inguinal, reducible hernia. Operation, 12, 2, 1892. Wound healed per primam. 1, 3, 1892, patient cannot be found.

58. A. F., aet. 30. Very large, left, oblique, inguino-scrotal, reducible hernia. Operation, 23, 2, 1892. Wound healed per primam. 1, 3, 1892, patient cannot be found.

59. K. H., aet. 30. Large, left, oblique, inguino-scrotal, reducible hernia. Operation, 4, 3, 1892. Wound healed per primam. A drop or two of pus about one stitch. 1, 3, 1893, patient cannot be found.

60. C. S., aet. 28. Small, right, oblique, inguinal, irreducible hernia. Operation, 11, 3, 1892. The wound healed per primam. 1, 6, 1892, patient cannot be found.

61. J. S. L., aet. 47. Large, left, oblique, inguino-scrotal, reducible hernia. Operation, 22, 4, 1892. Stitch abscess. 1, 3, 1892, patient cannot be found.

62. J. F., aet. 38. Very large, right, oblique, inguino-scrotal, strangulated hernia. Operation, 12, 5, 1892. The wound healed per primam. Patient had parotid abscess on both sides. Last observation, 22, 6, 1892, linear scar.

63. C. C., aet. 16. Small, left, oblique, inguinal, reducible hernia. Operation, 27, 5, 1892. The wound healed per primam. Last observation, 27, 6, 1892, linear scar.

64. M. W., aet. 45. Large, left, oblique, inguinal, strangulated hernia. Operation, 22, 5, 1892. Wound healed per primam. Last observation, 1, 9, 1892, linear scar, the hernia has not recurred.

65. T. M., aet. 33. Very large, direct, inguino-scrotal, traumatic, strangulated hernia. Operation, 24, 5, 1892. A gangrenous appendix vermiformis was excised. The wound suppurated. The patient was discharged, 2, 7, 1892, and cannot now be found.

66. T. McC., aet. 9. Small, left, oblique, inguinal, congenital, irreducible hernia. Operation, 27, 5, 1892. The wound healed per primam. Last observation, 23, 6, 1892, linear scar.

67. E. C., aet. 23. Right, oblique, inguinal, reducible hernia. Operation, 9, 6, 1892. The wound suppurated. Discharged, 4, 7, 1892.

68. J. McN., aet. 34. Large, right, oblique, inguino-scrotal, irreducible hernia. Operation, 10, 6, 1892. The wound healed per primam. Discharged for insolence, 25, 6, 1892. Last observation, 20, 2, 1893, linear scar, perfect result.

69. G. B., aet. 3. Small, left, oblique, inguinal, reducible hernia. Operation, 15, 6, 1892. The wound healed per primam except for a minute stitch abscess. Discharged, 7, 3, 1892.

70. J. N. W., aet. 21. Small, left, oblique, inguinal, reducible hernia. Operation, 16, 6, 1892. Wound healed per primam. Last observation, 1, 9, 1892, linear scar, perfect result.

71. C. S., aet. 58. Small, right, oblique, inguinal, irreducible hernia. Operation, 23, 6, 1892. The wound healed per primam. Discharged, 23, 7, 1892.

72. M. W., aet. 45. Small, right, oblique, inguinal, reducible hernia. Operation, 5, 7, 1892. The wound healed per primam. Last observation, 1, 9, 1892, linear scar.

73. H. R., aet. 25. Very large, right, oblique, inguino-scrotal, irreducible hernia. Operation, 9, 8, 1892. The wound healed per primam except for slight suppuration about one stitch. Discharged, 8, 9, 1892, well.

74. G. S., aet. 52. Small, left, oblique, inguinal, reducible hernia. Operation, 1, 9, 1892. The wound healed per primam. Discharged, 5, 10, 1892, well.

75. A. B., aet. 25. Left, oblique, inguinal, strangulated hernia. Operation, 6, 10, 1892. The wound healed per primam. Discharged, 1, 11, 1892.

76. W. K. H., aet. 43. Small, left, oblique, inguinal, reducible hernia. Operation, 29, 11, 1892. The wound healed per primam. Discharged, 27, 12, 1892.

77. C. C., aet. 22. Large, right, oblique, inguino-scrotal, reducible hernia. Operation, 13, 12, 1892. The wound healed per primam. Discharged, 18, 1, 1893.

78. A. E., aet. 5. Small, right, oblique, inguinal, reducible hernia. A recurrence after McBurney's operation in four months. Operation, 5, 12, 1890. The wound healed per primam. Last observation, 6, 4, 1892, the hernia has not recurred.

79. C. M. S., aet. 50. Large, right, femoral, strangulated hernia. Operation, 25, 12, 1892. Typical healing.

80. B. D., aet. 22. Large, left, oblique, inguinal, reducible hernia. Operation, 13, 1, 1893. Typical healing.

81. J. G., aet. 59. Very large, right, oblique, inguinal, reducible hernia. Operation, 10, 1, 1893. The wound healed per primam.

82. M. L., aet. 2. Large, right, oblique, inguinal, strangulated hernia. Operation, 29, 1, 1893. Typical healing.

The time has come when one may operate upon almost every case of hernia not only without danger to the patient, but also with an almost certain prospect of success. Those who, with Bull, have dropped the term "cure" may take it up again. That the mortality is practically nothing one may convince himself from the latest statistics.

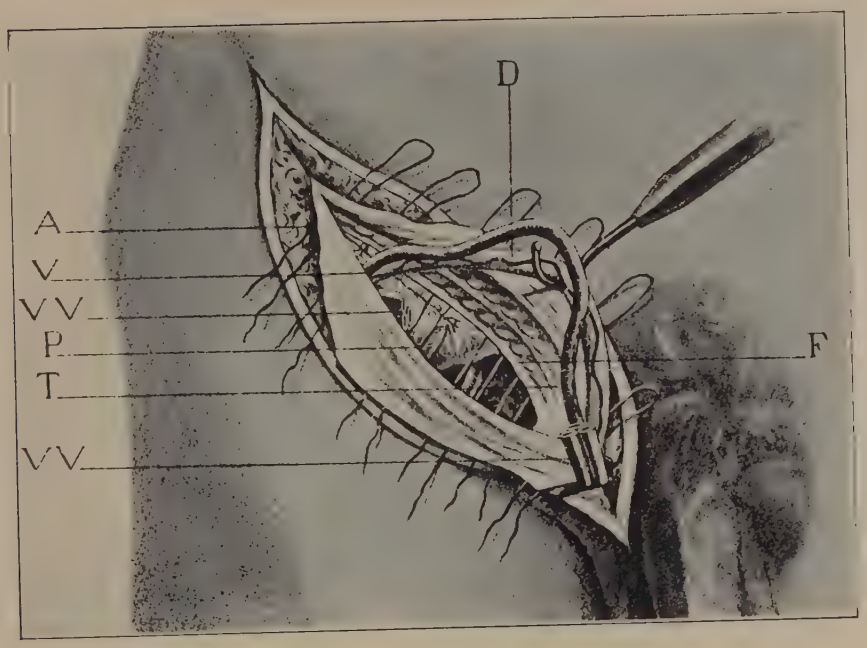
Svensson and Edman had from 106 cases one death from enteritis and nephritis on the tenth day when the wound was perfectly healed. McEwen operated 98 times for the cure of inguinal hernia, from 1879 to 1890. The only fatal case was that of a boy three years old who contracted scarlet fever after the operation and died within thirty-six hours. Bassini has operated 251 times for nonstrangulated hernia by his method, with but one death,

and this from pneumonia 15 days after the operation. The wound in the fatal case had healed per primam. Lucas-Championnière from 111 cases lost one from pneumonia. Kocher reports 119 operations for the radical cure of hernia with one death. The cause of death was pulmonary embolism 15 days after the operation and when the wound was perfectly healed. We have operated 82 times for the radical cure of hernia without a death.

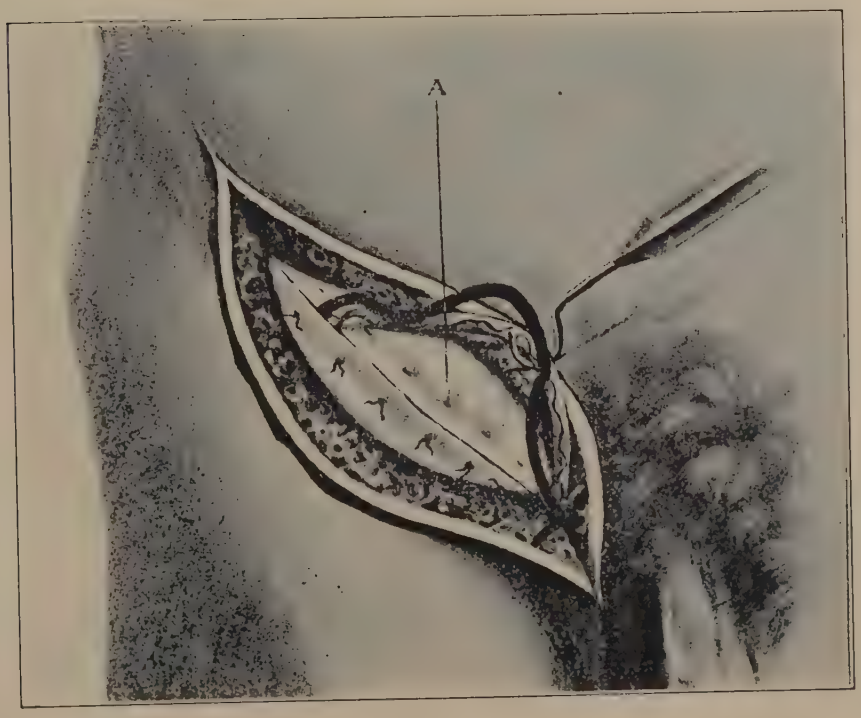
If it is objected that had it not been for the operation none of the deaths above enumerated would have occurred, we cannot positively deny it. But it is not improbable, as Kocher cleverly remarks, that if one should keep under observation hundreds of hernia cases of all ages and classes and present them every day with a good dinner, he would occasionally be able to announce a death among them. As to the ultimate results I shall refer only to those of McEwen, Bassini and myself. McEwen failed but once in 98 cases, and has had several cases under observation for ten years or longer. Bassini failed but seven times in 251 cases: one hundred and eight cases had been cured for from one to 4½ years, 33 from one year to six months, and 98 from six months to one month. In only four cases was the result unknown. It is now nearly four years that I have been operating for the cure of inguinal hernia in the manner just described by me, and thus far I have no failure to record, if we exclude the recurrences which I have reported and which could not be ascribed to my method.

Explanation of the Plates

A, Aponeurosis of the external oblique muscle.
D, Vas deferens.
F, Fascia transversalis.
P, Peritonaeum.
S, Buried skin-stitch, tied.
S', Buried skin-stitch, introduced but not tied.
T, Conjoined tendon.
V, Vein.
V, V, Stumps of excised veins.

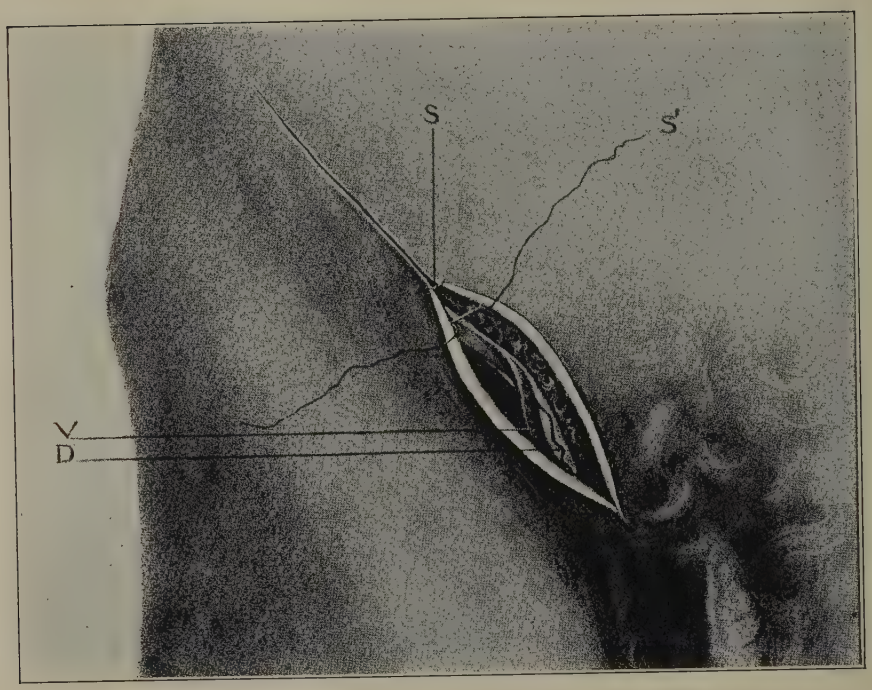


1.



2.

PLATE XXII



REPORT OF TWELVE CASES OF COMPLETE RADICAL CURE OF HERNIA, BY HALSTED'S METHOD, OF OVER TWO YEARS' STANDING. SILVER WIRE SUTURES[1]

Dr. Bloodgood has very kindly written to all of the old hernia cases in town and to several living out of town, requesting them to come to show themselves tonight. It is now nearly five years that we have done this operation for the radical cure of hernia. You may remember that a little more than a year ago we reported 89 cases of hernia, and that there were no recurrences in the cases of union by first intention. In 6 cases there was more or less of a recurrence, but all of these cases had suppurated for some reason or other, and had healed by granulation. It remains to be seen whether or not there are any returns amongst the cases here tonight.

This first man was operated upon only two weeks ago today. In this case and other recent cases we have used silver sutures instead of silk, not because we wish anything stronger than silk, but because of the results of experiments which Dr. Bolton has kindly made for us, and which we have made, to determine the power of different metals to inhibit the growth of bacteria. This line of experimentation is not entirely original with us. Dr. Bolton has found that zinc and cadmium and copper are perhaps the best metals to inhibit the growth of organisms. Silver is perhaps the next best metal, and we are using, therefore, silver wire altogether, both for deep buried sutures and for the continuous buried skin sutures. This is a beautiful instance of healing by first intention.

Since my last report of a year ago we have had a great many cases of hernia, and so far there have been, we believe, no recurrences.

Old Cases of Hernia Exhibited at the Medical Society

Case 1.—J. B., aet. 48. Had a very large right, oblique inguino-scrotal, reducible hernia of fifteen years' standing. Operation in August, 1889 (four years and six months ago). The bladder was caught in one of the stitches, and the wound consequently was laid open and allowed to heal by granulation. The scar now is firm, depressed, 12½ cm. long, and about 1 cm. in width, there is no impulse on coughing, no change in the cord or testicles, the man suffers no inconvenience from the wound.

[1] Presented at The Johns Hopkins Hospital Medical Society, Baltimore, May 7, 1894.

Johns Hopkins Hosp. Bull., Balt., 1894, v, 98-99.

Case 2.—F. F., aet. 7 (boy). Small, right, congenital, inguinal, reducible hernia. Operation in October, 1889 (four years and four months ago). Wound healed per primam; there is a narrow linear scar, no impulse on coughing, no change in cord or testicles, no discomfort from wound.

Case 3.—H. S., aet. 37 (colored). Large, right, inguinal, reducible hernia of two years' duration. Operation February, 1890 (four years ago). Healed per primam; there is a narrow linear scar 9 cm. long, firm, no impulse; the little fingers can detect the opening in the muscle through which the transplanted cord passes, no inconvenience from wound, no change in cord or testicles. Patient does heavy work.

Case 4.—E. P., aet. 7 (girl). Small, right, oblique, inguinal, reducible hernia of two months' duration. Operation November, 1890 (three years and four months ago). Healed per primam, except a small superficial stitch abscess; the scar is white, 11 cm. long and about ¾ cm. wide, firm; no impulse, no discomfort.

Case 5.—A. E., aet. 5. Small, right, oblique, inguinal, reducible hernia of four years' duration. Operation by Dr. Brockway (McBurney's method) in July, 1890. The hernia recurred, and in November, 1890 (three and one-half months afterward), a second operation by Halsted's method was performed. The wound healed per primam, notwithstanding the fact that the child had whooping-cough. It is now three years and three months since the last operation, and there is no return of the hernia.

Case 6.—F. S., aet. 27. Small, left oblique, inguinal, reducible hernia of two months' duration, following typhoid fever. Operation February, 1891. Healing per primam, except for a small superficial stitch abscess. It is now three years since the operation. The scar is firm, white, 12 cm. long. There is no impulse on coughing. No discomfort. Testicles and cord normal.

Case 7.—J. T., aet. 47. Small, right, oblique, inguinal, reducible hernia of six weeks' duration. Operation February, 1891 (three years ago). Healed per primam. The scar is narrow and white, 13 cm. long, firm. No impulse on coughing. No discomfort. Testicles and cord normal.

Case 8.—W. C. W., aet. 2½. Small, right, inguino-scrotal, congenital, reducible hernia. Operation July, 1891 (two years and eight months ago). Scar white, linear, 8 cm. long, firm. No impulse on coughing. No change in cord or testicle.

Case 9.—G. B., aet. 22. Right, oblique, inguino-scrotal, reducible hernia, noticed at birth; wore a truss from eight to thirteen years old. Operation August, 1891 (two years and seven months ago). The scar is 13 mm. wide and 12 cm. long, white, firm. No discomfort. On coughing there is a slight impulse at the lower end of the scar just above the pubes, corresponding to the external ring. There is no return of the hernia.

Case 10.—A. McI., aet. 26 (colored). Right, oblique, inguino-scrotal hernia, reducible for four years, strangulated on admission. Operation August, 1891 (two years and seven months ago). The veins were very large

and were excised; healing per primam, except at the upper end, in which there was superficial suppuration. November, 1893, hydrocele, on the same side, removed. The scar is firm; there is no impulse on coughing. No discomfort.

Case 11.—J. W. B., aet. 5. Small, left, oblique, inguinal, reducible hernia, following whooping cough at four months of age. Operation September, 1891 (two years and five months ago). The wound suppurated at its upper third and healed by granulation. The scar is 2 mm. wide (it has stretched some), is 8 cm. long, and firm. No impulse on coughing. Testicle and cord normal. There had been an epididymitis following the operation, the induration from which lasted for six months.

Case 12.—H. P., aet. 29. Small, right, inguinal, irreducible hernia of two years' duration. Operation October, 1891 (two years and five months ago). There were no adhesions in the sac. Wound suppurated and healed by granulation. There was a stitch sinus for three months. The scar is firm, but has stretched a little. It is 11½ cm. long. The abdominal walls of this patient are so very thin that on coughing there is an impulse above Poupart's ligament on both sides. The impulse is as great on one side as on the other.

THE OPERATIVE TREATMENT OF HERNIA[1]

The problem is to close durably a rent in the abdominal wall and to provide for the safe transmission of the spermatic cord. The cord is the first cause of the hernia and the ultimate obstacle to its cure. If we could ignore the cord, the solution of the problem would be comparatively easy. The larger the cord the greater the liability to a recurrence of the hernia. The size of the cord depends chiefly upon the veins. Then why not reduce the size of the cord by excising such veins as may be superfluous? By this procedure the cord may usually be reduced to less than one-third, and sometimes to one-fifth or one-sixth of its original size. Two quite distinct sets of veins accompany the vas deferens. When the tunica vaginalis propria funiculi spermatici has been divided and the elements of the cord are gently spread out by the fingers the larger superfluous bundle of veins lies at some distance from the vas deferens. A few very delicate veins hug the vas deferens closely. The veins which we designate as "superfluous" are those which I regularly excise in operations for varicocele. We have not thus far seen atrophy[2] of the testicle follow excision of these veins. Our cases have been observed with especial reference to this point. I think that there can be little doubt as to the advisability of reducing the size of the cord by excising these veins when they form a large bundle.

Let us consider next the closing of the hole in the abdominal wall. What tissues shall we employ and how shall we bring these tissues together? It has been demonstrated too often that the stitching of the pillars of the ring does not suffice. We must do more than bring free edges of the aponeurosis of the external oblique muscle together. Fortunately we have muscles so near at hand and so placed as to suggest at once a simple, and what has proved to be an entirely effective, plastic operation. After cutting through the anterior wall of the canal down to the sac, we continue the incision in the same line, outward and a little upward, through the internal oblique and transversalis muscles for an inch or less. We divide the muscle-bundles about at right-angles to their long axes. Thus two flaps of muscle are obtained, which we draw down into the canal and include in the deep stitches

[1] Am. J. M. Sc., Phila., 1895, n. s., cx, 13-17. (Reprinted.)

[2] May 15, 1895. In three of our cases atrophy of the testicle has been caused by the operation. The atrophy is probably due to the excision of the veins, for it has occurred thus far only in the cases in which the veins were excised.—W. S. Halsted.

in the way to be described. The uppermost bundles of the cremaster muscle are often so heavy that we can use them for the same purpose. We close the rent which nature has made and which the knife has enlarged with mattress sutures, precisely as we close all abdominal wounds. The mattress suture is to be preferred to other sutures because it constricts the tissues less, holds greater surfaces in contact, and insures, ultimately, more accurate apposition of the several planes of tissue. These stitches bring surfaces together at the outset, just as in sutures of the intestines the walls of the intestine, irrespective of the stitch, are always brought together. The walls of the intestine are so inverted that the muscular surfaces (so-called peritonaeal surfaces) are extensively in contact, the cut edges never. And yet after a few weeks no trace of the inversion remains. Sometimes an almost imperceptible dark line is left to indicate the position of the cicatrix. With the aid of the microscope we see that the finest layer has met its fellow and may be traced uninterruptedly through the cicatrix, and were it not for the rudimentary character of a few of the villi we might search in vain for evidence of the solution in continuity.

Dr. Mall,[3] for whom I performed some experiments which necessitated circular suture of the intestine, describes the microscopical appearance of an intestinal suture of sixty-four days as follows: "Fig. 12 shows a section of this suture which strikes the stitches. Were it not for this stitch and a slight infiltration of that part with leucocytes the point of suture could not be made out. To be sure, the microscope shows very rudimentary villi which could easily be overlooked when compared with the other folds which this intestine contains. The crypts are fully regenerated and cannot be differentiated from the surrounding crypts. The stratum fibrosum, muscularis mucosae, submucosa, and two muscular coats are all reproduced and form one straight line. The regeneration is so complete that the two layers of the regenerated muscularis mucosae can be made out."

There are usually six of these deep stitches. They are taken very close together, not more than 1 cm. apart. The two arms of each stitch are 7 or 8 mm. apart. The vas deferens, with its arteries and remaining veins, is brought forward between the two outermost stitches. These two stitches are closer together than the others and embrace the cord snugly. The outer arm of the outermost stitch is sometimes passed through uncut muscle.

When the deep wound is closed muscle should be seen throughout the greater part of it, projecting between the cut edges of the aponeurosis of the external oblique muscle. These edges are then made to embrace the cord more snugly at the point where it passes between them by two very fine

[3] Johns Hopkins Hospital Reports, vol. i, p. 90.

stitches. The skin incision is closed with an uninterrupted suture. As we approach, in stitching, the lower inner angle of the deep wound the muscle becomes thinner and finally gives out. The aponeurosis of the external oblique, with perhaps a few fibres of the cremaster, is all that is left for the innermost stitch. If the aponeurosis at this point shows, as it sometimes does, a tendency to split when it is vigorously pulled upon by a stitch, we gather or pucker it up by taking running mattress sutures in place of the ordinary mattress sutures. In running the stitches I try to avoid perforating the aponeurosis. The puckering is, of course, only a temporary affair, but the running stitches enable us to close the lower angle of the deep wound with less damage to the aponeurosis.

In short, we close our hernia-wounds precisely as we close all wounds of the abdomen, except that in hernia alone we stitch the peritonaeum separately. In wounds of the linea alba we split the sheaths of the recti muscle, whether we are operating for the cure of hernia or not, that we may oppose broad surfaces of muscle throughout the whole length of the incision.[4] For the same reason, and also that we may transplant the cord in the male and the round ligament in the female, we divide the internal oblique and transversalis muscles when operating for the cure of inguinal hernia.

I shall say but a few words at this time about our results, for Dr. Bloodgood will soon publish a complete report of them.

We have operated one hundred and sixty-five times for the cure of various forms of hernia in both sexes without a death from the operation. One hundred and six males with inguinal hernia have been operated upon by my method. The wounds, with few exceptions, have healed absolutely per primam. Thus far we have been unable to find a single recurrence in cases whose wounds healed per primam. The case which furnishes the nearest approach to a recurrence was operated upon about three years ago and is now under daily observation. The man has the physiognomy of a Hindoo, but is classed as a negro. He is about thirty-five years old, not much more than half-witted, and was on admission, and still is, much emaciated and exceedingly feeble. Within the first twenty-four hours he got out of bed. Possibly he repeated this act of disobedience daily. The wound healed absolutely per primam. There is at present, but only on coughing, a bulging of the very thin, flabby abdominal wall from the inner almost to the outer end of the scar. The local condition is not bad enough to demand a second operation.

[4] In a recent number of the Centralblatt für Chirurgie, P. Bruns, of Tübingen, describes and recommends a method for the cure of ruptures in the linea alba which, except that he does not employ the mattress sutures, is identically ours for closing all incisions in the linea alba.

I dislike to have my operation referred to as a modification of Bassini's operation. The operations are undoubtedly original with both of us, and mine was described several months before we had heard of Bassini's operation. You may know that in my operation the cord which is transplanted out into the thicker muscle lies superficial to the aponeurosis of the external oblique muscle, and not, as in Bassini's operation, in a fold of and under this aponeurosis. In Bassini's operation the circulation of the aponeurosis must be impaired, both by the foldings of the aponeurosis near Poupart's ligament and by the stitches which temporarily maintain them. Furthermore, Bassini's method does not, as he claims, reestablish the obliquity of the canal. Bassini believes that he restores the inguinal canal to its physiological condition when he makes "a canal with two openings, an abdominal and a subcutaneous opening, and with two walls, a posterior and an anterior, through the middle of which the cord passes obliquely." But the original canal is not by any means an affair so simple as Bassini's. To reproduce the equivalent, anatomically and physiologically, of the inguinal canal is for us impossible.

For about one year I have sewed all of my hernia wounds with silver wire and have covered them with silver-foil. Without exception the wounds have healed absolutely per primam. Not a single stitch abscess has been observed either during or subsequent to the healing of the wound. Such absolutely perfect healing of the hernia wounds we have not had heretofore, and I am convinced that the use of silver as a suture material has contributed somewhat to this result. We have tested the effect of silver on the growth of the more common pyogenic organisms. I have here two Pétri-plates which Dr. Bolton has kindly prepared for me. They have both been inoculated with *Staphylococcus pyogenes aureus*. In the centre of each plate is a piece of silver-foil, such as we use on our wounds. Just outside, and completely surrounding the foil, is a perfectly clear zone several millimetres wide. Except for the clear zone and a slightly intensified zone just outside of this, the agar is quite uniformly cloudy. The cloudiness is due to the growth of the microorganisms with which the agar has been inoculated. Dr. Bolton has studied the effects of various metals on the growth of bacteria, and has recently read a most interesting paper on this subject before the Association of American Physicians. With cadium, zinc, and copper, Dr. Bolton observed that the inhibitory action was greater than with silver. Prior to my knowledge of Dr. Bolton's experiments I tried to use copper and brass foil for protective, and copper and brass wire for sutures; but these metals corroded the tissues so much that I soon stopped using them. We do not hesitate to employ buried sutures of silver wire in sewing tissues on the confines of an infected region. In cases of acute suppurative appendi-

citis, for example, we close the wound in the abdominal wall with deep, interrupted, buried sutures.[5] These wounds are drained by a few strips of gauze. Two of the sutures are taken very close to this gauze, and sometimes must pass through tissues which are infected. Not even in such cases have we ever had a stitch abscess. Once a silver stitch and once a silver bone-plate, having been exposed to view and to the air by necrosis of the overlying tissues, were allowed to remain and to become imbedded in the granulations of the wound, which healed by suppuration. Neither the stitch nor the plate at any time caused the slightest disturbance in the tissues or inconvenience to the patient.

We have already observed much in the use of silver wire that is worth recording and enough to satisfy us that it will play a new and more important rôle in the surgery of the near future.

[5] *Vide* Bulletin of The Johns Hopkins Hospital, November, 1894.

THE OPERATIVE TREATMENT OF HERNIA[1]

Inasmuch as our president requests it, I shall add a few words to Dr. McBurney's exceedingly complimentary remarks on my operation for the cure of inguinal hernia. It was devised at a time when McEwen's and McBurney's operations were the only ones which seemed to promise a fair measure of success.

My operation is nothing more or less than a substantial sewing up, in a very simple and natural manner, of a rent in the abdominal wall. We enlarge a little the rent already made in order to obtain the muscle-flaps which we draw down between the cut edges of the aponeurosis of the external oblique muscle, and to enable us to transplant the cord into the thick muscle.

I am glad to have this opportunity to tell you that in three of our cases atrophy of the testicle has been caused by the operation, and to caution you against excising the veins too indiscriminately. It has occurred thus far only in cases in which the veins have been excised. For the present we shall not excise the veins if they do not contribute much to the size of the cord.

It may be possible to exercise such care in isolating the vas deferens and its vessels as to prevent the occurrence of even an occasional atrophy of the testicle.

I maintain, with Dr. McBurney, that the sac should be opened in most if not in all of the cases. There are at least three good reasons for this:

1. There may be a constriction of peritonaeum higher than the internal ring. This is not a rare condition. I have encountered it at least twice this year.

2. Very often adhesions, particularly of omentum, are found at the neck of the sac which might not be recognized if the sac were not opened.

3. The sac can be sewed at a higher point and without danger of wounding the intestine with the needle.

Three weeks is not too long a time for the patient to remain in bed. I have experimented on animals to try to determine this point, and consider that four weeks, if possible, would be better than three. A wound younger than twelve days can usually be torn open with the fingers with ease.

[1] Remarks in discussion of Dr. Christian A. Fenger's paper, "Causes of hernia of the bladder met with during operations for inguinal and femoral hernia." American Surgical Association, New York, May 28-30, 1895.

Tr. Am. Surg. Ass., Phila., 1895, xiii, 343-344.

THE CURE OF THE MORE DIFFICULT AS WELL AS THE SIMPLER INGUINAL RUPTURES[1]

This communication will, I hope, be of interest to friends who have asked for precise information as to the modifications which our operation for hernia has undergone in the process of development during the past thirteen years, and of service to operators who seek to obtain in each instance a result as perfect as possible and who recognize that not infrequently there occur cases of hernia requiring for their cure extraordinary operative procedures. The present operation has been evolved by degrees and stands for the experience of 14 years derived from more than 1000 operations for the cure of inguinal hernia; features of the old where they seemed unnecessary have been dropped and new ones, as they seemed to be indicated, added. To record even the cruder general results of so many operations (upon adults with few exceptions)[2] for the cure of inguinal hernia are required special training, some zeal and a particular honesty of purpose; and for the recognition and interpretation of the nicer facts, keen perception and fine tactile sense are indispensable. A few drops or even a dram of fluid in the tunica vaginalis might readily escape detection, and to determine slight swelling or induration here and there in the epididymis and the relative size of the two testicles may be difficult. A novice can usually discover a distinct recurrence and so can the patient, but I have known an eminent surgeon to overlook a weakness in a scar of his own making sufficient to constitute, without doubt, a recurrence. The surgeon is fortunate and likely to be true to himself whose observations are controlled by mature assistants with large experience in the operative treatment of hernia and who are as eager as he to ascertain and state the exact truth.

[1] Johns Hopkins Hosp. Bull., Balt., 1903, xiv, 208-214. (Reprinted.)

(Note.—This article has special reference to the transplantation of the sheath of the rectus.—Editor.)

[2] The value of an operation for the cure of inguinal hernia can hardly be determined upon children for the surgeon is greatly assisted by nature as the child develops, and he is not confronted with the more difficult problems arising from an undeveloped or an acquired atrophy of the conjoined tendon, or from fatty degeneration and atrophy of the internal oblique muscle. Furthermore, the recurrences have almost invariably followed operations for the cure of very large and old ruptures, such as are impossible in children. And to quote from Bloodgood, "As we have had no recurrences" in children "whether the veins have been excised or not, it does not seem to make much difference what is done with the very small cord."

If our operation for the radical cure of inguinal hernia has improved, it is due in no small measure to the arduous labors of Dr. Bloodgood, whose valuable contribution [3] should be better known. He established several facts of prime importance from his study of our first 300 cases of inguinal hernia. The majority of inguinal ruptures are now easily and quite well cured by a variety of procedures and by the average operator, hence it is difficult for the student and young practitioner to comprehend that it is hardly more than a decade since this variety of hernia completely baffled the efforts of the best surgeons to cure it. That so simple an operation as Kocher's can cure perhaps many of the milder ruptures, provided the neck of the sac is not too wide, leads to the inquiry whether the features, of these operations, upon which most stress has been laid may not be relatively unimportant, since operations of the magnitude of Bassini's and the author's are not in all cases indispensable. If the transplantation of the neck of the sac can cure so many cases, is it not possible that the transplantation of the cord, which at first was deemed so essential by Bassini and the author, may have owed its success in part to the fact that it made possible this very high closure of the sac's neck? Although for several years our operation, so far as transplantation of the cord and high closure of the sac is concerned, was even more radical than Bassini's (the cord was transplanted into the substance of the divided internal oblique muscle), we were tempted, at the very outset, to test the relative value of cord transplantation in some of the cases, and permitted the entire cord to lie undislocated and altogether undisturbed in its bed and to trust to the suture of the internal oblique muscle to Poupart's ligament, to the "lining of the wound with muscle" to effect a cure. It was well worthy of note, as Bloodgood emphasizes in his article, that all of the cases treated in this manner (cord undisturbed) remained cured. Another fact which Bloodgood's painstaking study established was that of one hundred and nine cases in which the larger bundle of veins of the cord was excised and the healing was per primam, not one showed a recurrence or any weakness at the site of the transplanted vas deferens, whereas in 6.4 per cent of the cases which healed by first intention and in which the veins had not been excised, there was a recurrence at the upper angle of the wound, at the site of the transplanted cord. And even in the wounds which suppurated, there was not a recurrence in the nine cases of vein excision, whereas, of eleven suppurating cases in which the cord-veins were not excised, four (36.3 per cent) recurred. In 118 cases, therefore, in which the larger bundle of veins was excised there was no recurrence at the

[3] Johns Hopkins Hospital Reports, vol. vii.

site of the transplanted cord whether suppuration [4] occurred or not. And, certainly, the cases in which the veins were excised, were not the simpler ones.

One of the most important of the facts ascertained by Bloodgood was the great variation in the width of the conjoined tendon and the responsibility of the insufficient tendon for the recurrences at the lower angle of the wound, through the external ring, direct. The transplantation of the rectus muscle recommended by Bloodgood [5] to close this defect seems to accomplish what its originator hoped it might, although, a priori, one would fear that this powerful straight muscle must eventually draw away from Poupart's ligament to which it had been sewed. Is it not conceivable, however, that a new encompassing fascia may develop about a transplanted muscle and that this fascia may remain even after the muscle has been pulled away? Experiments upon animals to determine this point would be interesting. M. Holl, now Professor of Anatomy in Gratz, directed attention many years

[4] Nine suppurations in 118 cases, and for most of which the author was personally responsible, seems a large percentage (7.6%) even for hernia cases ten years ago, but it was considered a good showing in those days. Since every one, including the operator, has invariably worn rubber gloves, suppuration, even in the operations for hernia, has occurred in probably less than 1% of the cases. In 1890, all the assistants at an operation, the nurses and physicians, systematically wore gloves, but the operator wore them only for special operations, such as exploratory laparotomies, explorations for foreign bodies, loose cartilages, etc., in the joints, suture of the fractured patella, etc.—in other words, when there was a possibility of doing serious harm and no certainty of doing great good. By degrees the operator wore gloves more frequently, until Dr. Bloodgood as resident surgeon, and who had become thoroughly accustomed to them as assistant, wore them invariably as operator and demonstrated from our statistics the necessity of doing so. It seems to be a fact that one who has been trained to operate always in rubber gloves finds it awkward to operate without them. I have more than once heard my assistants, while performing some insignificant operation without them, call for gloves because, as they said they were conscious of unnatural finger movements, of a certain clumsiness without them. With gloves one probably acquires special methods of tying knots, holding instruments, etc. In our clinic the heavier gloves are exclusively used, although probably every member of the staff has by predisposition been in favor of the thinner gloves and had to convince himself by trial of the thinner varieties that the thick ones, even with seams on the fingers, were preferable. The thin gloves were too slippery; also too unsafe, chiefly because of the danger of minute undetected holes. Cotton gloves, if changed very frequently, are undoubtedly better than no gloves at all. If the operator desires the physical property of the cotton which enables him to hold more securely and handle with more precision the intestines and viscera he might wear a very delicate gauze-mesh glove over the rubber or over two or three fingers of the rubber glove. Possibly a rubber glove might be manufactured with a wide gauze mesh permanently imbedded in its palmar surface.

[5] Anton Wölfler, Beiträge zur klinischen Chirurgie (Festschrift f. Billroth), 1892.

ago to the part muscles probably play in the determination and development of the fasciae.

Hence, so long ago as 1896 we recognized, thanks to Bloodgood, the value of the excision of the veins of the cord and the necessity for paying more attention to the neglected lower angle of the wound. Naturally, it was primarily to the upper angle that we had devoted our thoughts, for, as emphasized in one of the author's articles on the subject, "the cord is the first cause of the hernia and the ultimate obstacle to its cure." And this is true, notwithstanding the fact that recurrences at the lower angle were at first not very rare; for, our attention having been called to these lower angle recurrences, methods to cure them were soon found.

The success attending excision of the veins (one hundred and eighteen cases without recurrence at the site of the transplanted vas deferens) seemed to justify a continuance of this practice, provided it occasioned no undesirable results; but excision of the veins with transplantation of the vas deferens taught us that, not infrequently, a hydrocele, usually insignificant in size, was to be expected, and that in about 10 per cent of the cases atrophy of the testicle had occurred. Atrophy of this organ, however, was observed only in cases complicated by a very considerable swelling of the epididymis, and this observation of Bloodgood's, made so many years ago, has been verified by our study of more than one thousand operations. Great care was exercised, therefore, in excising the veins and, for a short time, a few months perhaps, this procedure was not so invariably practised by all of us, being reserved for cases which seemed imperatively to demand it. We formerly handled the cord as, I presume, almost everyone still does; separated it, more or less roughly, by tearing, from the sac and its enveloping membranes, and raised it on a hook or strip of gauze preparatory to transplantation and while the stitches were being applied. We now treat the vas deferens with great deference, thanks again to Bloodgood. (*Vide* description of operation below.)

It occurred to Bloodgood before the publication of his report on hernia that it might be well to split the cord, transplanting only the veins to the outer angle of the wound and permitting the vas deferens to lie undisturbed. This method was finally abandoned by Bloodgood and other members of the staff who had practised it, because the subtraction of the vas deferens did not appreciably reduce the size of the cord; furthermore, there was one or two recurrences at the site of the transplanted veins. This is a particularly good confirmation of the author's belief that the veins are largely responsible for the development of oblique inguinal hernia. The vas deferens contributes, relatively, very little to the size of most adult cords, but the veins, which at one moment make a bundle as large as one's finger, may the next

and when empty be reduced to the size of a small quill. Is not this variation in the size of the cord possibly a factor in the production of hernia? When the hernia is first developing and the sac is, at operation, inside the internal abdominal ring, it can readily be demonstrated by a little pull on the veins. The fat, too, which is recognized as sometimes a probable factor in the production of hernia, accompanies for a short distance the veins rather than the vas deferens. This fat when present should be excised with the veins. For several years, then, we have been excising the veins in this careful manner, leaving the vas deferens untransplanted, undisturbed, and the internal oblique muscle undivided. In a few cases, however, without, that I am aware of, ultimate damage to the testicle, we transplanted the vas deferens to the outer angle of the wound. But we are quite certain that, as a rule, the less the vas deferens is manipulated and the more carefully the veins are excised, the less is the subsequent congestion of the epididymis. It is instructive from day to day to study the stump of the veins, the epididymis, the testicles, etc., after operations for hernia.

It is not the purpose of this communication to give the results in detail of these observations.

In a recent private case, urethritis Neisseri made its appearance a few hours after the operation. We naturally watched the epididymis on the operated side with some concern, fearing that excision of the veins might lower the resistance of this organ. On the twelfth day, without warning, a very slight induration of the epididymis became evident. I attributed this to the fact that the patient carried out his irrigation-treatment badly, for the proper [6] method of irrigation being instituted, the swelling of the epididymis immediately subsided and the urethral discharge promptly ceased.

[6] When the author's method of treating gonorrhœa can fail in his own wards, because improperly understood, it is not strange that so admirable a surgeon as Dr. Orville Horwitz, apropos of Janet's work on the abortive treatment of gonorrhoea by permanganate of potash, should write: "In spite of the claim of quick cures and prevention of complications a length of time elapsed before it began to be generally adopted in this country. The profession was skeptical as to the claims made for its brilliant results. This was probably due to the disappointment which had followed the employment of retroinjections of hot water suggested by H. Holbrook Curtis, and of the continuous irrigation with a hot solution of mercury bichloride, recommended by Dr. W. S. Halsted, which at the outset seemed to offer more benefit to the patient than the conservative methods then in vogue, but resulting after a fair trial by a large number of observers in being found valueless and often dangerous; the employment of these remedies having been found to be attended with great discomfort to the patient and being frequently accompanied by severe complications, such as acute posterior urethritis, seminal vesiculitis, prostatitis, and cystitis." This is not the proper time to tell how one must use the bichloride solutions in order to obtain the best results which have been claimed for it, but to judge from my own experience with this method twenty years ago in private practice, too much has hardly been said in

Four years ago the author used, for the first time, a part of the aponeurosis covering the right rectus muscle to close the lower part of the right inguinal canal. I felt compelled in this case to resort to some such measure, for the internal oblique was fatty and attenuated to a degree not very often seen by us, and the rectus muscle did not seem to promise so much as its fascia did. This patient was a college-mate of mine and for this reason I wished, perhaps, more than ever, to be very sure of the result. One year ago I examined this patient very carefully and was gratified to find as solid a closure as one could desire. I considered the result as perfect as any that I had seen. Dr. Harvey Cushing, house surgeon at the time, made a sketch of this act of the operation, which Brödel has kindly elaborated (*vide* Plate XXVI). This procedure may have a wider application than I have proposed for it. The anterior sheath of the rectus muscle might be employed in the way described whenever the conjoined tendon is insufficient, whether the cremaster muscle can be well used to remedy the defect or not. And Berger [7] has recently suggested using the rectus sheath in much the same way in operations for the cure of inguino-interstitial hernia.

In the upper part of the canal we have strong tissues and plenty with which to close, and hence it was perhaps natural to transplant the cord to the upper angle, to bring it out through thick muscle. But it is not perfectly certain that the cord may not be a useful adjunct in the closing or filling in of the lower angle in some cases, and it is a fact that with Bassini's operation the percentage of recurrence at the position of the transplanted cord in the case of adults has been quite large, probably over 6 per cent. Whatever the truth may be, we have in the excision of the veins a distinct contraindication to transplanting the vas deferens, and thus far we have had no reason to believe that the results would have been better if the vas deferens had been transplanted, as was our custom for several years, to the outer angle of the canal. We may eventually discover that the transplantation of the cord, which Bassini, and at one time the author, considered not only so important, but perhaps the principal feature of the operation, is harmful rather than helpful. Briefly, we may find that not only the vas deferens, but even the entire cord, would be more safely transmitted at the lower angle of the deep wound than at the upper. It would require a very large number of observations to determine this point because the percentage

its favor. The bad and indifferent results probably come from mismanagement or misconception. I should be glad at some future time to publish the treatment in detail, for it happens that I have not heretofore described or, in print, claimed anything for the method which rightly bears my name. I agree with Dr. Horwitz that irrigation with hot water is not only useless but dangerous.

[7] P. Berger: La Hernie inguino-interstielle et son traitement par la Cure radicale. Revue de Chirurgie, Janvier, 1902.

of recurrences is so small in these days; and it is unfair to compare the results of various operations in the hands of various operators. Surgeons do not seem to be agreed even as to what shall constitute a recurrence, or wound suppuration, and, if they were agreed, the personal element would still count for much.

The Use of the Cremaster Muscle.—A device which we hit upon in our efforts to close more securely the lower part of the canal, but which we now make use of as often as feasible, probably in over 75 per cent of the cases, is the utilization of at least a part of the cremaster muscle, which we formerly cut away. This is a step of the operation to which one is irresistibly drawn in some cases by the great strength of the cremaster and the firmness and extent of its attachments to Poupart's ligament. A natural insertion, such as this, of the cremaster and its fascia into Poupart's ligament, has in each case a value which can be demonstrated on the operating table and can be counted upon definitely to contribute something, and occasionally perhaps a great deal, to the strength of the abdominal wall; whereas the artificial insertion of the internal oblique into Poupart's ligament, although undoubtedly of the utmost importance and always to be tried for, may occasionally and perhaps often fail, from insufficient muscle, too great tension, or gradual redressment, to close securely even the upper part of the canal. The lower part of the canal, ordinarily protected by the conjoined tendon, can rarely be entirely safeguarded by the muscle fibres of the internal oblique when its conjoined tendon is deficient. The cremaster, on the other hand, seems in just these cases to serve a particularly good purpose. The cremaster, unaided, has repeatedly made such a complete and strong looking closure that we have felt the hernia would be well cured if the operation were abandoned at this stage.

I have today, June 10, 1903, examined a patient whose very wide inguinal canals (the gap would have admitted the hand) were closed eighteen months ago solely by the cremasters stitched over instead of under the internal oblique muscle; the result, in the opinion of those who examined the case, is absolutely perfect, on both sides. My house surgeon, Dr. Follis, and one or two others examined the man[8] with me. Even had I known what the result

[8] The history is briefly this. Male, aet. 59 years; Surgical No. 12,905; was operated upon January 15, 1902, for two very large scrotal ruptures, eighteen and twenty-four inches long (from external ring to bottom of scrotum). The conjoined tendons on both sides were almost obliterated. The circumcentral rings easily admitted four fingers. The cremaster muscles, very well developed, were used to close the entire dehiscence because the internal oblique muscles could, only with great tension, be drawn down to Poupart's ligament; the former was stitched in front of instead of behind the latter muscles. We had never before and have never since had occasion to use the cremasters in this way. Dr. Mitchell, my house surgeon, operated upon one side, and the author upon the other.

in this case was to be, I would have used, if possible, the internal oblique muscles in the old way, and hence have stitched the cremaster under rather than over the former. But the muscles were attenuated and not close at hand. Stitching the cremaster over the internal oblique muscle necessarily precludes the sewing of the latter to Poupart's ligament. The closure with the cremaster seems almost ideal in some cases; it is a method so inviting during the operation, and so true, when finished, to one of the *great principles of surgery; there is no tension.* It is, in this respect, as a plastic operation should be. What the ultimate verdict will be it is too soon to predict. The cremaster fibres, particularly the hypertrophied ones, will, in time, atrophy; but when this occurs, the cremasteric fascia, perhaps stronger than before, would probably remain, holding together the atrophied muscle bundles. There can, at least, no harm result from this attempt to strengthen the wall, for the internal oblique muscle has been used in the usual manner. The worst that could happen would be a recurrence, in a certain class of cases, at the lower angle, one that might, possibly, have been avoided if the aponeurosis over the rectus muscle had been employed instead of the cremaster as described by the author. The future will decide these nicer points, and it would seem that only the nicer points remain now to interest the operator.

Another feature of the present operation is to transplant the neck of the sac as described below. It is merely an additional precaution warranted by the good results obtained by Kocher and others with his operation.

And, finally, we overlap the aponeurosis of the external oblique muscle to insure the union which a mere approximation of the edges of the aponeurosis cannot do, and to close more snugly the external ring.

We still examine with the same care, but no longer with concern, the epididymis, testicle, stump of veins, etc., chiefly to ascertain if there is congestion (induration) of the epididymis or fluid in the tunica vaginalis. Often there is an appreciable, though very slight, induration of the epididymis, particularly if the veins have been ligated through the dense plexus very near the testicle; and often a few drops or a drachm or two, or even more fluid is present in the tunica vaginalis. This may become absorbed in a few weeks or months and might, when present, usually not be noticed by the patient except for the repeated careful examinations. Hydroceles containing several ounces have been recorded in our histories; in two or three instances operation for the cure of the hydrocele has been performed. What the proportion of hydroceles is to the cases operated upon for the cure of hernia, without vein excision, I cannot say for the reason that we excise the veins almost invariably nowadays, and in the days when the veins were not excised we did not observe our cases quite so keenly with reference to this

point. One of the larger hydroceles followed, as I have said, an operation in which the veins were neither excised nor transplanted nor in any way disturbed. The patient, a navy officer, had an indirect rupture on each side. Both sides were operated upon at the same time and on both, hydroceles developed in a few days, although neither epididymis became more than just perceptibly indurated; but the larger hydrocele was on the side of the undisturbed veins and of the smaller hernia. Not a single atrophy of the testicle has been recorded since 1899, when Bloodgood published his report, and I believe that at that time it was noted that not one had been observed for several years.

Possibly some of my readers will ask, "Why take so much trouble, why make the operation so complicated when such good results as are published may be obtained by simpler methods?" The operation is not complicated for the surgeon competent to operate for the cure of hernia, nor are all its details required for the simpler cases, and we do not know just what the results obtained by simpler methods are. We cannot ascertain definitely even our own results, although we make a great effort and are admirably equipped to do so. This can be said, however, that, since the publication of the author's second paper, June, 1892, not a single recurrence has been charged to him. One of the world's most distinguished surgeons, the inventor of a clever hernia operation, made, with reference to himself, some such remark to the author three or four years ago, and the next morning two recurrences presented themselves. This surgeon permits his patients to get out of bed in eight days because, as he said to me, "A man can better afford to be operated upon three or four times for recurrence by my method than once by a method like McEwen's, which requires lying in bed for five or six weeks." In my experience a man would, *after* operation, prefer to spend several additional weeks in bed than run the risk of a recurrence. It is only before, not after the operation that a patient objects so vigorously to the time to be spent in bed.

The Operation.—The several steps of the operation are so well depicted by the illustrations of Brödel that a verbal description is almost superfluous for those who have the plates.

(I) The aponeurosis of the external oblique muscle is divided and the two flaps reflected as in the Bassini-Halsted operation.

(II) The cremaster muscle and fascia is split, not directly over the centre of the cord, but a little above it.

(III) The internal oblique muscle is made as free as possible. A little artefaction is here often necessary. If the muscle cannot be drawn, without tension, well down to Poupart's ligament, it helps, I think, to make a relaxation cut or two in the anterior sheath of the rectus muscle under the aponeurosis of the external oblique muscle. This sheath being in part the

aponeurosis of the internal oblique muscle, one can readily comprehend that incisions into it, if properly made, might be of service. It is well, however, to postpone making such incisions until the sewing of the internal oblique muscle to Poupart's ligament is begun, for then the amount of tension can be nicely gauged and the number, length and precise position of the relaxation cuts determined. A second reason for postponing the relaxation incisions into the anterior sheath of the rectus muscle is that we sometimes use this portion of the rectus sheath to close the lower part of the inguinal canal, as already stated.

(IV) When the veins are large, and this is usually the case, they should be excised with very great care to avoid even the slightest extravasation of blood into the tissues about the smaller veins and about the vas deferens which they accompany. And the vas deferens, as first emphasized by Bloodgood, should not be raised from its bed or handled or even touched, lest thrombosis of its veins occur.[9] (*Vide* Plate XXV, 2.) The veins should be ligated as high up in the abdomen as possible, being pulled down quite firmly just before the ligature (in a needle with the blunt end first) is passed between them. As a precaution against slipping, we apply two ligatures of fine silk, both for the abdominal stump and for the testicle stump of the veins. The farther from the testicle the veins are divided, the better, provided, of course, that their stump is external to the external abdominal ring.

(V) Ligation of the sac by transfixion or by purse-string suture at the highest possible point. Both ends of this suture, after tying, are threaded on long curved needles, then carried far out under the internal oblique muscle from behind forwards, and, passing through this muscle, about 5 mm. apart, are tied. The idea was suggested to the author by Kocher's operation, the principle being essentially the same.[10]

(VI) The lower flap of the cremaster muscle and its fascia is drawn up under the mobilized internal oblique muscle and held in this position by very fine silk stitches, which, having engaged firmly a few bundles of the cremaster, perforate the internal oblique, preferably where it is becoming aponeurotic, and are tied on the external surface of the latter; *vide* Plate XXIII, 1.

(VII) The internal oblique muscle, mobilized, and possibly further released by incising the anterior sheath of the rectus muscle, is stitched (the

[9] The fact is that the vas deferens is frequently accidentally handled or squeezed, but harm that we know of has never resulted since we have recognized the necessity for exercising great care in the separation and ligation of the veins.

[10] I have read recently in the Centralblatt für Chirurgie a reference to some other surgeon's account of this very procedure, but, unfortunately, cannot recall the surgeon's name and have not the facilities at this moment to hunt for it.

conjoined tendon also) to Poupart's ligament in the Bassini-Halsted manner. (*Vide* Plate XXIII, 2.) Catgut is usually employed for this suture. The drawing was made from an unusually muscular subject and possibly exaggerated the size and extent of the internal oblique muscle, as well as of the cremaster, although the artist endeavored to record accurately what he saw.

(VIII) The aponeurosis of the external oblique muscle is overlapped, as shown in Plate XXIV, 1 and 2. This is known as Andrew's [11] method, although devised independently by us.

(IX) The skin is closed with a buried continuous silver suture, and the incision covered with five or six layers of silver foil. It is unnecessary to dress or examine a wound closed in this manner for two weeks, when the wire may be withdrawn. Patients are kept in bed from eighteen to twenty-one days.

We hope to be able to publish very soon the results of the first 1000 operations performed for the cure of inguinal hernia at The Johns Hopkins Hospital. Certainly more than two-thirds of the operations have been performed by my associates, Drs. Finney, Bloodgood, Cushing, Mitchell and Follis, for we are all much interested in the subject. Each operator has been at perfect liberty and is encouraged to perform the operation according to his best judgment. This fortunately furnished a little variety, but of late the operation has, in almost every detail, been performed just as the writer has described it.

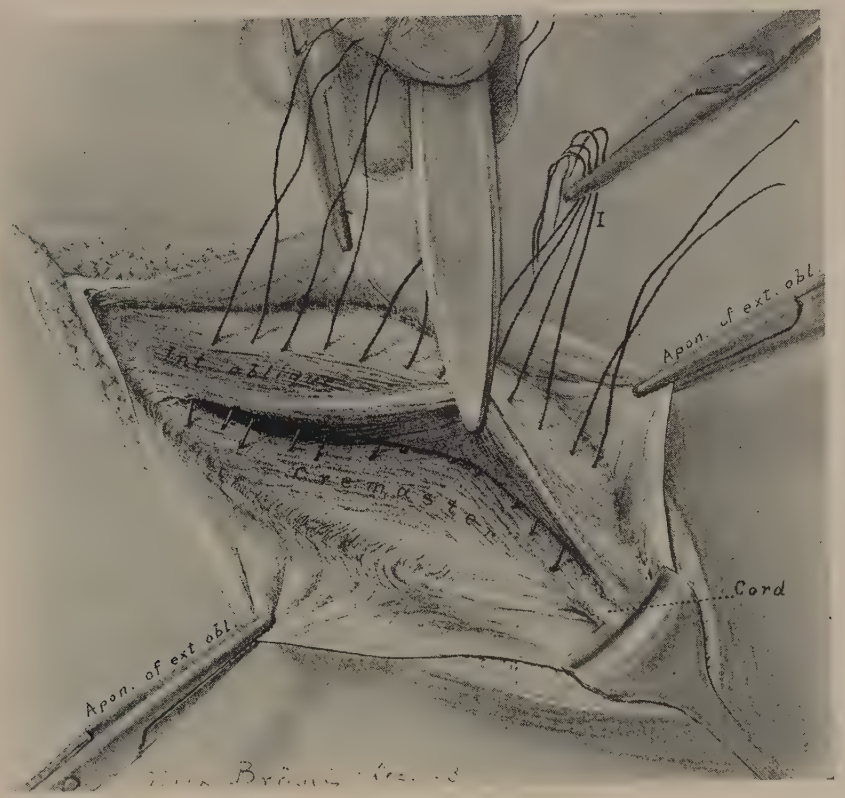
Inasmuch as only a limited number of surgeons see The Johns Hopkins Hospital Reports, in which Dr. Bloodgood published his article, it may be well to publish one or two of the Summaries which he prepared with such care and so great labor. He intends quite soon to investigate the condition of all those, so far as possible, who are included in these Summaries.

"Summary of the Ultimate Results. Complete to June 1, 1899

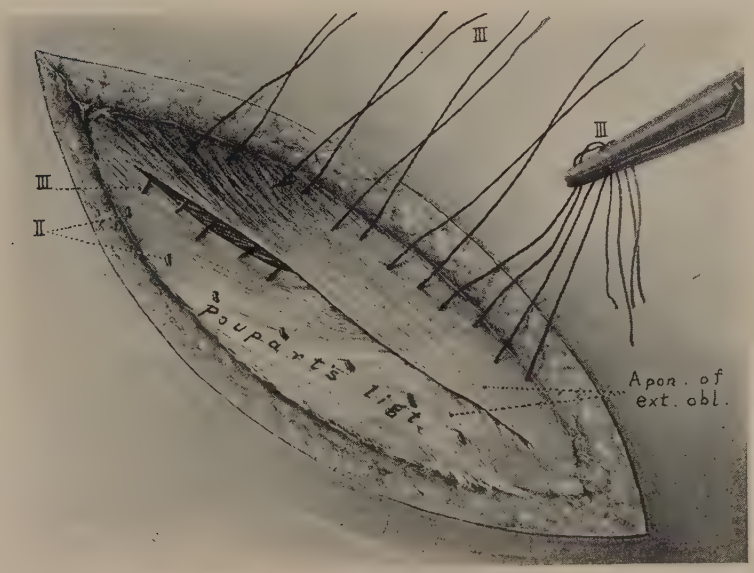
"Recent cases, less than 6 months, and cases lost track of were not included.

All cases, Group I to V, healing p. p.	301 cases.	13 recur.	4.3%
All cases, Group I, suppurating	31 "	9 "	29%
Total	332 "	22 "	6.6%
Halsted's operation, Group I, healing p. p.	218 cases.	9 recur.	4.1%
Halsted's operation, Group I, suppurating	20 "	6 "	30%
Total, Group I	238 "	15 "	6.2%

[11] The Chicago Medical Recorder, August, 1895, vol. ix, p. 67.

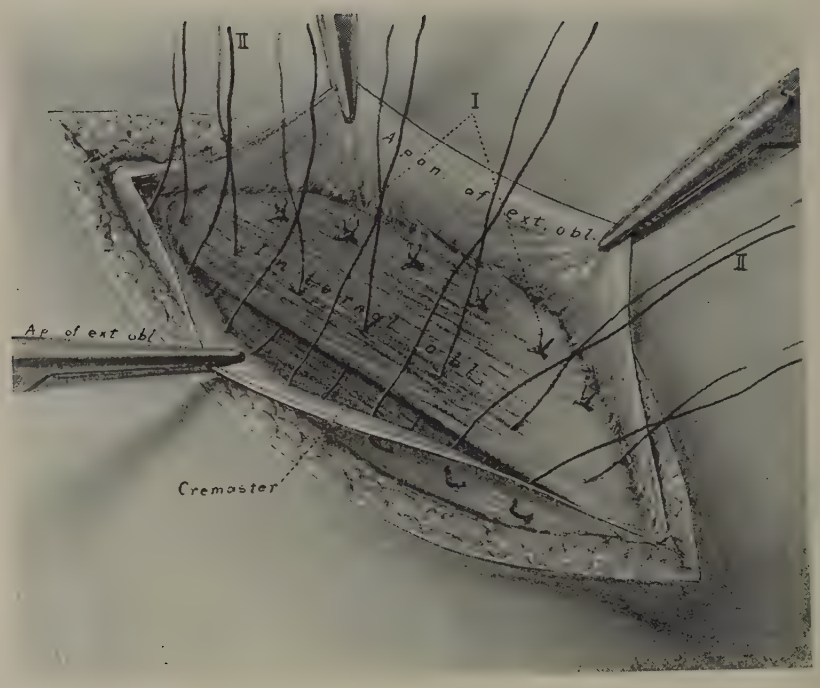

I
Apon. of ext. obl.
Int. oblique
Cremaster
Cord
Apon. of ext. obl.

1.

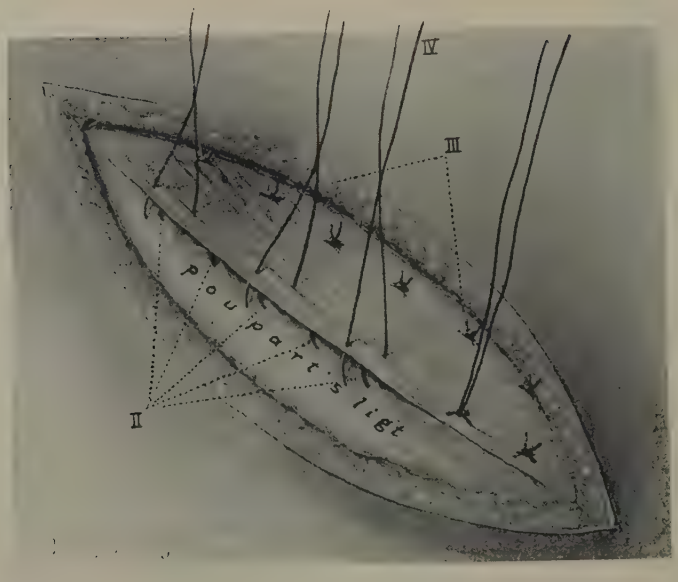

III
III
III
II
Poupart's ligt.
Apon. of
ext. obl.

2.

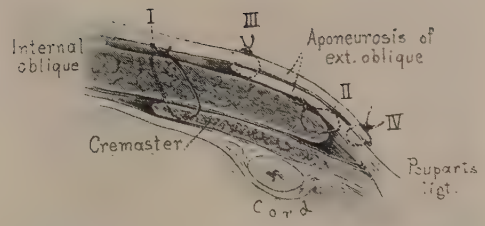
PLATE XXIV



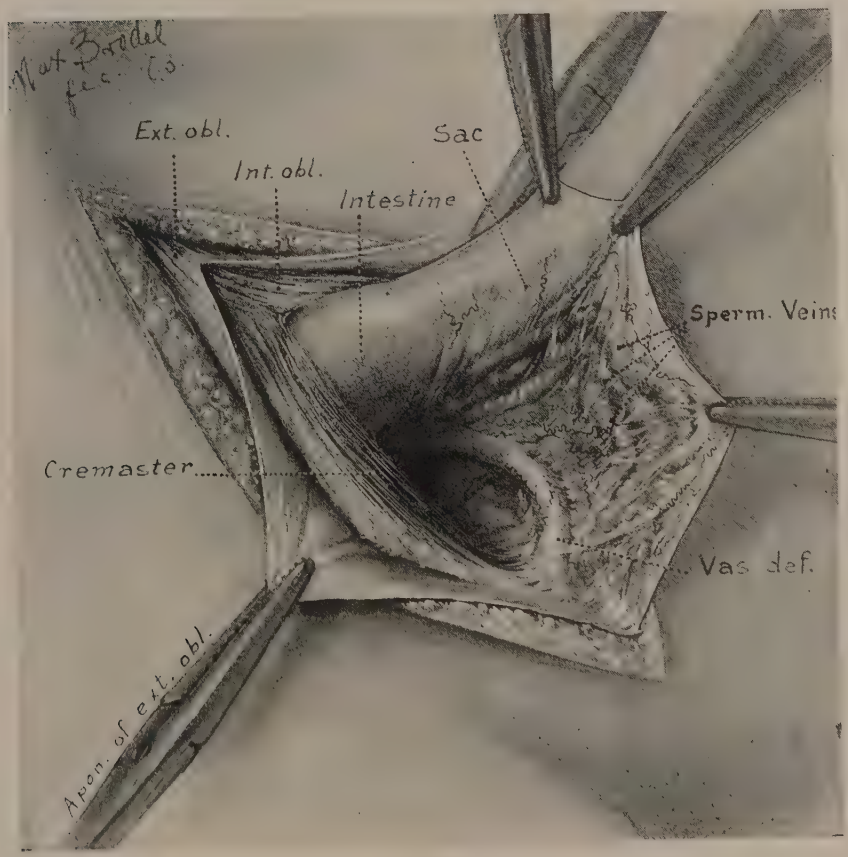
1.



2.

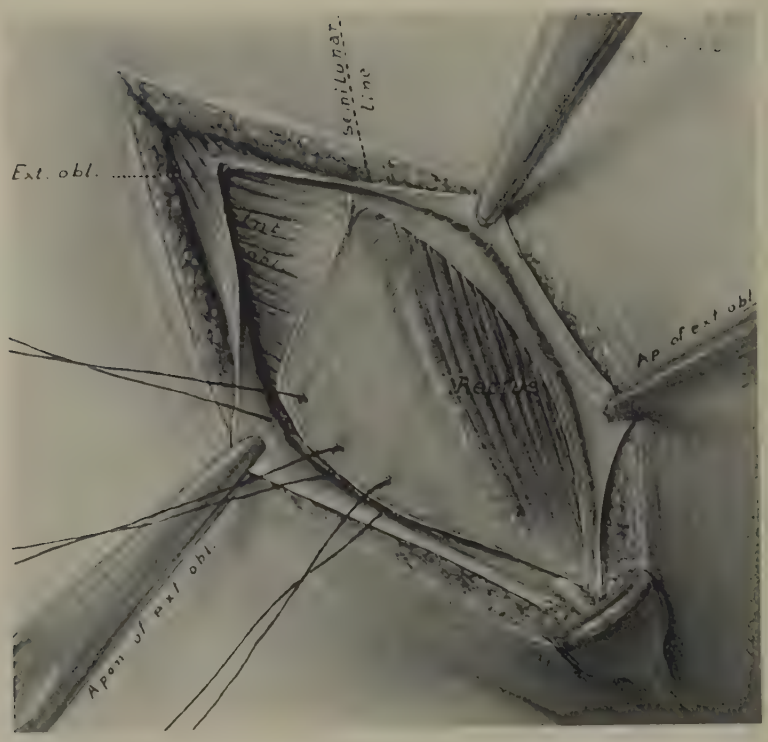

I
III
V
Internal oblique
Aponeurosis of ext. oblique
II
IV
Cremaster
Poupart's lig.
Cord

1.


Ext. obl.
Int. obl.
Intestine
Sac
Sperm. Veins
Cremaster
Vas def.
Aponeurosis of ext. obl.

2.

PLATE XXVI



"Recurrence in Wounds Healing Per Primam

	Cases.	Recurrences.
(1) At the position of the transplanted cord, veins excised	109	nil.
(2) At the position of the transplanted cord, veins not excised	109	7 (6.4%)
(3) Upper angle of the wound, cord excised or not transplanted	83	1 (1.2%)
(4) Lower angle of the wound, conjoined tendon wide and firm, rectus muscle not transplanted	264	nil.
(5) Lower angle of the wound, conjoined tendon obliterated, rectus muscle not transplanted	8	5 (62%)
(6) Lower angle of the wound, conjoined tendon obliterated, rectus muscle transplanted	14	nil.
(7) Lower angle of the wound, conjoined tendon wide and firm, rectus muscle transplanted	16	nil.

"Recurrence in Wounds Healing by Suppuration

(1) At the position of the transplanted cord, veins excised	9	nil.
(2) At the position of the transplanted cord, veins not excised	11	4 (36.3%)
(3) Upper angle of the wound, cord excised or not transplanted	11	1 (9%)
(4) Lower angle of the wound, conjoined tendon wide and firm, rectus muscle not transplanted	27	2 (7.4%)
(5) Lower angle of the wound, conjoined tendon obliterated, rectus muscle not transplanted	4	2 (50%)

Dr. Bloodgood's "*Conclusions as to the operation for inguinal hernia,*" published in 1899:

"Our observations prove that Halsted's operation with the excision of the veins will give perfect results, except in those few cases in which the conjoined tendon is obliterated; in these cases our observations so far have demonstrated that the transplantation of the rectus muscle will give perfect results.

"If the veins could be excised in every case of inguinal hernia and the remainder of the cord transplanted without any risk of epididymitis and atrophy of the testicle, a perfect result would probably be accomplished in every case.

"The operation would then be: The ligation and excision of the veins, the transplantation of the remaining portion of the cord into the upper angle of the divided and transplanted internal oblique muscle, and, in cases in which the conjoined tendon is obliterated, the transplantation of the rectus muscle. So far we have not observed a single recurrence when these procedures have been adopted. The sole objection to this method is the danger of atrophy of the testicle after excision of the veins. Atrophy of the testicle has been observed only after a very marked epididymitis. The proba-

bilities of this epididymitis are very much less when the veins are excised without disturbing the vas deferens and its immediate vessels. For this reason I should advise that when the veins are excised the remainder of the cord, a very small affair, be left undisturbed. I am very much inclined to believe that the cord, reduced to such a diminutive size by the excision of the veins, will be as little likely to be the cause of a recurrence in the lower angle of the wound as in the upper angle when it is transplanted.

" Cases in which the Veins should not be Excised

" When during the dissection of the sac the cord is torn from its bed in the inguinal canal and subjected to traumatism, and the testicle withdrawn from the scrotum, the veins should not be excised, because the probabilities of epididymitis and atrophy are too great. In such cases I would advise the transplantation of the veins alone, so that the larger cord is divided,[12] and the wound is weakened less by the presence of a very small cord in two places than by the presence of a larger cord in one place, which from our results we know to have been the cause of a recurrence in 6.4 per cent of the cases.

" Note, June, 1899. In October, 1898, I performed for the first time the splitting of the cord, transplanting the veins only. Since this date the modification has been followed in 26 operations for inguinal hernia. In 12 the rectus muscle was transplanted. The wounds in 25 cases healed per primam. In 19 cases no swelling of the testicle followed operation. In 7 cases there was slight but temporary swelling. Thrombosis of the veins was not observed in any of the 26 cases. It is seven months since the first two operations. Both are perfect results. The others are recent operations.

" When the bundle of veins is unusually large, and complete excision is contraindicated for reasons already given, I have suggested that a portion should be ligated and excised and the remainder transplanted. This has been done in a recent case by Doctor Cushing.

" In children the veins should not be excised; the probability of atrophy is greater than in adults. As we have had no recurrences whether veins have been excised or not, it does not seem to make much difference what is done with the very small cord.

" In the female the round ligament and its vessels is such a small affair that it makes little difference what is done with it.

" References to the transplantation of the rectus muscle by Wölfler: Wölfler published his method of transplantation of the rectus in 1892 in the Beiträge z. Festschrift f. Th. Billroth. I did not see this publication until my colleague, Dr. Clark, returned from Germany, in June, 1898. My preliminary report had then just been published. For this reason no mention was made of Wölfler's work. In the Archiv für klinische Chirurgie, June, 1898, Dr. Slajmer publishes 150 operations after the Wölfler method. A careful reading of these two articles has convinced me that this method of transplantation of the rectus differs from mine. In the first place no special reasons are given for the transplanting of the rectus muscle, while

[12] The splitting of the cord has been discontinued by its author.

in my publication the reason given for the transplantation of the rectus is to strengthen the lower portion of the inguinal canal by the introduction of muscle which is weakened by the obliteration of the conjoined tendon. The description of the Wölfler method and the illustration on page 912 of the second article show that the rectus muscle is not transplanted in the best way to strengthen the lower portion of the wound, because the sheath of the rectus is not divided down to the symphysis pubis; but the division of the sheath ends at least 2 to 3 cm. above the pubic bone. For this reason the transplanted rectus muscle is approximated chiefly over the upper two-thirds of the wound. In addition, Wölfler divides the sheath of the rectus on the anterior surface above the linea semilunaris. In my method the sheath of the rectus is divided posteriorly and the belly of the muscle is brought out behind the internal oblique. I believe that by this method the muscle can better be transplanted so as to occupy the lower two-thirds of the wound. Slajmer reports 6 recurrences, about 6 per cent. In three of these cases the wound suppurated."

AN ADDITIONAL NOTE ON THE OPERATION FOR INGUINAL HERNIA[1]

The following references are to Bassini's first publications of his method for curing inguinal hernia:

Edoardo Bassini. Nuovo metodo operativo per la cura radicale dell'ernia inguinale. 106 pp. Padua, 1889. Month is not stated.

Eduardo Bassini, Prof. der klin. Chirurgie an der Königl. Universität zu Padua. Ueber die Behandlung des Leistenbruches. Arch. f. klin. Chirurgie, 1890, Bd. 40, p. 429.

My first cases were reported at a meeting of The Johns Hopkins Hospital Medical Society, November 4, 1889, and were published in The Johns Hopkins Hospital Bulletin for January, 1890. Hence Bassini's brochure anticipated my first report by at least a month or two. Whether my first operation was performed before the appearance of Bassini's pamphlet in Italian I cannot say, for the precise date of the pamphlet is not given. In any event I had not heard of Bassini's operation until his German article appeared—possibly about one year after my first operation; neither was I or any American or German, so far as I know, aware of Bassini's first report until the appearance of the second. Bassini unquestionably has the priority. Our operations differed in several respects, but in the essential features were the same. He transplanted the cord out to the position of the internal ring; I divided the internal oblique and occasionally the transversalis muscle and transplanted the cord to a point considerably external to the site of the internal ring. We both sutured the internal oblique muscle to Poupart's ligament; Bassini placed the transplanted cord between the internal oblique muscle and the aponeurosis of the external oblique, whereas in my operation it was carried superficial to this aponeurosis. Bassini stressed the importance of restoring the obliquity of the canal, but this his operation did not do, nor can it be done. At the very outset in some of the cases I omitted the transplantation feature of the operation, preserving the others (the division of the muscles, the high ligation of the sac, the suturing of the muscles to Poupart's ligament), trying to determine the essential details of the operation in case it proved successful. It soon occurred to me that it might be well to reduce the size of the cord by excising the greater of the

[1] Prepared by Dr. William S. Halsted, August 26, 1922.
Not previously published.

two bundles of veins which accompany the cord. But after a time this procedure was abandoned because hydrocele followed it in about 20 per cent of the cases. We found that the direct hernias recurred more often than the indirect and hence Bloodgood practised suturing the outer fibres of the rectus muscle to Poupart's ligament in order to fill the defect caused by the obliteration or attenuation of the conjoined tendon. Unknown to Bloodgood or me Wölfler had made use of this device some months earlier. I never approved of this procedure, believing that the rectus in contracting would pull away from the abnormal position, and hence in place of the muscle fibres used a flap formed from its anterior sheath. Some years later I found that Berger, a French surgeon, had anticipated me by a few months in using this flap of fascia. Later I improved the operation by overlapping the aponeurosis of the external oblique and underlapping (under the internal oblique) the split cremaster muscle (*vid.* Broedel's beautiful drawings). The best studies of the ultimate results of operations for hernia are, undoubtedly, the monograph of Bloodgood (The Johns Hopkins Hospital Reports, 1899) and the paper by Taylor (Archives of Surgery, vol. I, no. 2). Bloodgood traces the development of the operation and gives the results for the first ten years or so, and Taylor continued the study up to about 1919. Taylor's paper teaches several things, the most significant being the fact that the best results were obtained by the resident surgeons who conscientiously observed all the details of my operation in its final form. Their percentage of recurrence is about 2.5. The worst results were by "A" and "B" (20 to 28 per cent). "A" adhered to the Bassini operation and "B," proclaiming incessantly that any operation would cure hernia, made light of the details upon which I insisted. Dr. Cushing made an important contribution in performing the operation under local anaesthesia. He blocked the nerves as I had done in other operations. The reviewers of Taylor's paper have without exception missed almost all of the lessons which it teaches.

It gratified me to note that in twenty years I have probably not had a recurrence. This is the more remarkable because most of these cases were operated upon between ten and twenty years ago. It would weary you to have me discuss this subject farther; but I have spoken only of points which are essential to a superficial understanding of the subject. We have been unable to demonstrate that the transplantation of the cord is advantageous and hence, years ago, discarded this detail of the operation. Obviously it is better to leave the cord undisturbed in its bed unless it can be proved that transplantation of it gives the better results. Dr. Karl Schlaepfer tells me that the German surgeons, with few exceptions, have not abandoned the transplantation of the cord. Bassini has made no contribution to the

subject, I am quite sure, since 1890. There is not in any language a study of the ultimate results, or of the relative importance of the various details of the operation comparable to ours. Indeed I have not seen a single paper since Bassini's which contributed anything new. Kocher's operation and Leisrink's, although clearly not advisable, tend to strengthen my conviction that the most important feature of the operation is the high ligation of the sac. Prior to Bassini's publications inguinal hernia had rarely been cured. The best operation up to that time was McEwen's. This was in a measure a subcutaneous operation and so difficult to perform that it was rarely undertaken by others; but it necessitated a high closure of the neck of the sac because in making a pad of the folded sac which he sutured at the site of the internal ring he undoubtedly closed off the neck of the sac at a high point. He cured nine(?) cases, some of them for five years or more, as I recall the facts. His operations were in the days when surgeons hesitated to make long incisions and free exposures and careful dissections of the region. I shall be interested to ascertain McEwen's early attitude towards antisepsis. I have an impression that he was not an ardent supporter of Lister at the outset. The cure of inguinal hernia may be listed with the triumphs of surgery.

SURGERY OF THE BLOOD VESSELS

AND

EXPERIMENTAL SURGERY OF THE LUNGS

LIGATION OF THE FIRST PORTION OF THE LEFT SUBCLAVIAN ARTERY AND EXCISION OF A SUBCLAVIO-AXILLARY ANEURISM[1]

Dr. Halsted exhibited the patient and gave the following history:

Levin Waters (Plate XXVII), colored, aet. 52 years, was admitted to the hospital April 30, 1892. Patient is a vigorous man, gives a good family history and denies having had syphilis. Perfectly well until eight months ago; he then noticed a small swelling about the size of a madeira nut under the left clavicle. He is sure that there was at this time a distinct pulsation in the tumor. He "could feel it beat like his heart" when he put his fingers upon it. The tumor has grown rapidly since it was first observed. Until one month before the operation the patient worked regularly, did heavy lifting, etc., and had experienced little or no discomfort from the aneurism. His only symptoms were a slight numbness of the left hand and forearm, and, subsequently, a shortness of breath and a hoarseness—both of which he attributed to a cold.

Patient says that he has never had a pain which could be referred to the tumor.

On admission, the patient had an almost spherical, perfectly smooth tumor under the left clavicle. It was somewhat flattened on the side which pressed against the chest wall, and measured 42 cm. in circumference at its base. The middle third of the clavicle was overlapped and almost concealed by the tumor; the lower margin of the tumor touched the fourth rib.

Internally it extended to within 5 cm. of the left sterno-clavicular articulation, and externally to within 4 cm. of the coracoid process. The skin over the tumor appeared to be normal. It was only after careful inspection that pulsation could be seen. To the touch the tumor was quite solid but elastic, and it was not easy to feel the feeble expansile pulsation. No pulse could be felt at the wrist nor anywhere below the aneurism. The left arm was neither swollen nor perceptibly cooler than the right. The cut gives one a very good idea of the size and situation of the tumor.

The Operation.—The skin incisions: 1. *Horizontal,* about 33 cm. long, from the sternal notch to the acromioclavicular articulation, and thence down the arm to the lower border of the major pectoral muscle over the greatest convexity of the tumor. 2. *Ascending, vertical,* about 5 cm. long, from the inner end of the horizontal incision. 3. *Descending, vertical,* about 10 cm. long, from the middle of the horizontal incision. 4. *Ascending, vertical,* about 4 cm. long, from the horizontal incision at the acromioclavicular articulation.

[1] Presented before The Johns Hopkins Hospital Medical Society, Baltimore, May 23, 1892.

Johns Hopkins Hosp. Bull., Balt., 1892, iii, 93.

The flaps so outlined were reflected: the first, upwards and outwards; the second, downwards and inwards; the third, downwards and outwards. The inner third of the clavicle was then excised. The middle third of the clavicle was somewhat eroded by the aneurism which overlapped it a little.

The wall of the aneurism was inflamed, soft, and so very thin where it pressed upon the bone that it would have been imprudent to attempt to dissect this part of the clavicle from the tumor.

The next step in the operation was the deligation of the left subclavian artery. This portion of the artery had been drawn down by the tumor, so as to occupy a horizontal position rather than a vertical one. It was entirely concealed by the subclavian vein, and lay below and behind the vein instead of above and behind it. I thought for a moment that it might be necessary to excise a portion of the first rib to expose the artery. Two strong silk ligatures were applied to the artery as it emerged from the chest, and the vessel was divided between them. The deltoid muscle was cut through a little below the clavicle, and the clavicle sawed through at about $2\frac{1}{2}$ cm. from its outer end. The aneurism, the greater part of the clavicle, a piece of the deltoid muscle and about 6 cm. of the subclavio-axillary vein were then removed in one piece. The vein was intimately adherent to the aneurism. The axillary artery was ligated at the beginning of its second part. The operation as a whole was a tedious one and consumed $3\frac{1}{2}$ hours. The wound was closed with interrupted buried skin sutures of fine black silk. The large dead space incompletely covered by the skin was bridged over with gutta-percha tissue.

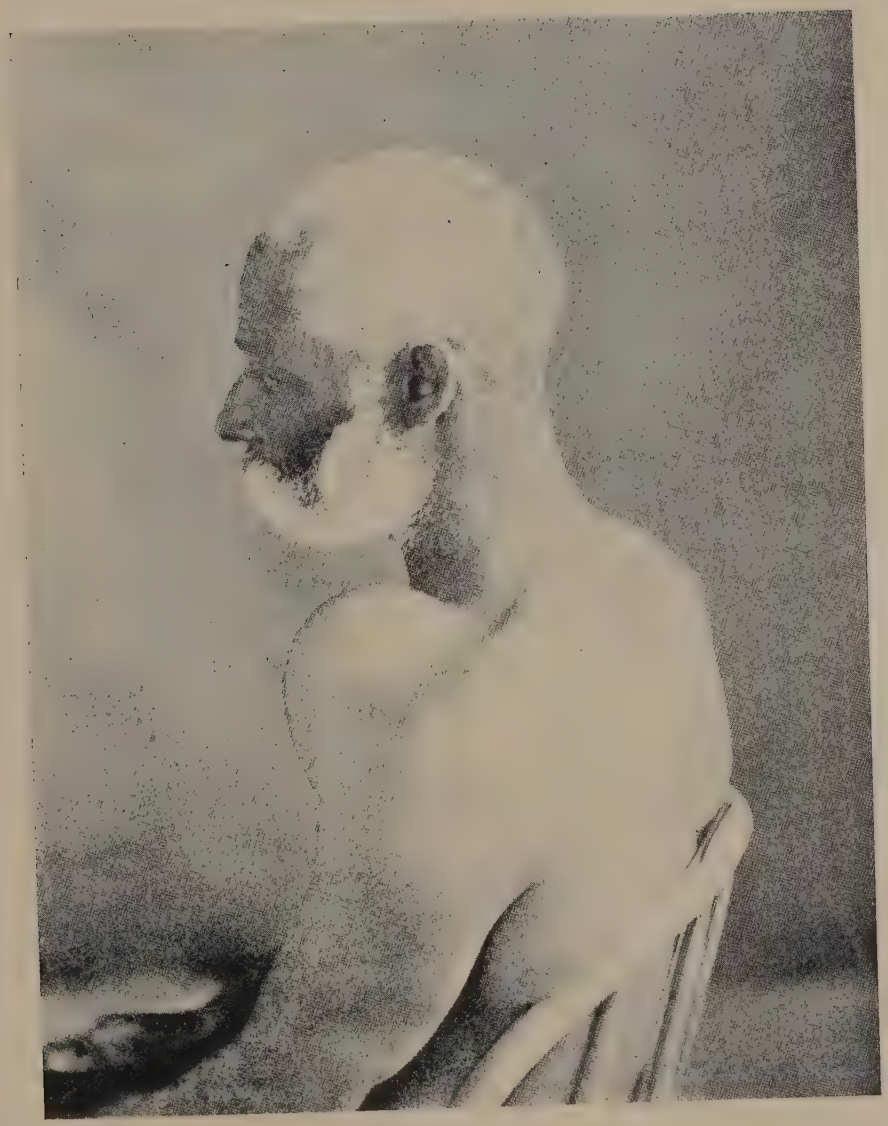
This is the aneurismal sac and this the laminated clot which occupied and almost completely filled it. The aneurism is, as you see, a so-called true aneurism.

At this the second dressing, 13 days after the operation, it may be observed that the dead space is almost completely filled with a blood clot. This clot has not broken down and is almost completely replaced by granulation tissue. The patient has not had an unpleasant symptom since the operation.

The left arm has never swelled and has at no time been cold. For a few days only there was a slight numbness of the tips of the fingers and particularly of the thumb. The case was altogether a most fortunate one for operation in that, thanks to the clot which occupied the sac, the collateral circulation had already been well established.

This case is, perhaps, the only successful one of deligation of the first part of either subclavian artery, and the first one of complete extirpation of a subclavio-axillary aneurism.

The deligation of the first part of the subclavian artery has been effected once before, in 1846, by Dr. Kearney Rodgers of New York, and attempted once by Sir Astley Cooper. Dr. Rodgers' case terminated fatally on the 16th day from secondary haemorrhage. "At the autopsy a large irregular lacerated opening was found in the pleura and the cavity was filled with coagulated blood." "The artery had been completely divided by the liga-



Levin Waters.

ture which was found loose in the wound. The stump of the subclavian, between the aorta and the ligature, presented the appearance of a round, solid cord about one and a quarter inches long, impervious to water and air." Beyond the ligature no plug other than a soft, quite recent clot occupied the lumen of the artery; the vertebral was given off immediately at the point of ligature and contained a little clot, evidently formed only just before death; the internal mammary, also, was patulous and healthy."

Sir Astley Cooper abandoned the attempt to tie this vessel, thinking that he had wounded the thoracic duct.

The first part of the right subclavian has been deligated twelve or more times, with a fatal result in each case. At least nine of the cases died of secondary haemorrhage from the distal side of the ligature.

I find practically but one comment from surgeons on these results, viz., if absorbable ligatures had been used and if the coats of the artery had not been divided, the mortality from secondary haemorrhage might have been less. I would suggest, rather, that the aneurism be excised.

NOTE.—July 9th, 60 days after operation. The wound has healed in an ideal way. The numbness at the tip of the left thumb has not completely vanished. No pulse as yet is to be felt at the wrist. The patient has an excellent use of his arm.

THE PARTIAL OCCLUSION OF BLOOD VESSELS, ESPECIALLY OF THE ABDOMINAL AORTA[1]

A PRELIMINARY REPORT

At the meeting of The Johns Hopkins Hospital Medical Society, on March 20, 1905, a brief preliminary report was made of the results of a large number of experiments performed in the past year by Dr. Sowers and myself upon the abdominal aorta and other large blood vessels of dogs.

It had occurred to one of us that possibly the aorta might be successfully occluded in man if the operations were undertaken in several acts instead of one. The notion of gradual compression in the ordinary use of the term was entertained only to be definitely discarded because of the seemingly insurmountable difficulty of preserving asepsis. A sinus must form about any instrument leading from the aorta to the air, and, sooner or later, such a sinus necessarily becomes infected. The method, therefore, should, we thought, be one permitting, in each entr'acte, complete closure of the wound; the apparatus or material to be applied to the aorta should not be bulky nor endanger, by its form or substance, the adjacent parts; and it should admit of easy readjustment at subsequent operations. Metal bands of silver and aluminum were employed with the belief that at each operation the amount of constriction could be regulated to a nicety. With the aid of a clever jeweler an instrument was devised to curl the metal strip, *in situ,* in perfect cylinder-form, about the vessel. The tightening of the band, the cylindrical form being preserved with great care, was completed with fingers and tweezers, but ultimately, when narrower bands were used, the tweezers could, fortunately, be discarded. The instrument for curling the band was also in the majority of cases finally dispensed with.

We attempted rather persistently but unsuccessfully to determine accurately the blood pressure in the femoral arteries during and after the application of the band; and Dr. Haller is now devising and constructing for us an instrument on the principle of the Erlanger instrument to enable one to determine the blood pressure in small and large arteries without dividing them. Calculations, therefore, as to the amount of occlusion were roughly determined by the fingers on the aorta and femorals.

[1] Presented before The Johns Hopkins Hospital Medical Society, Baltimore, March 20, 1905.

Johns Hopkins Hosp. Bull., Balt., 1905, xvi, 346-347.

For some weeks we feared that the sharp edges of the bands would cut through the pulsating and constricted aorta, and considered several methods to obviate, if necessary, this danger. On the twelfth day of the operation a dog died from haemorrhage, the result of ulceration at the upper edge of the band and we feared that the procedure might be doomed; but no further cases of haemorrhage occurring, we resumed, in a few weeks, the experiments. Then, after about 3 months, investigating in several dogs the conditions at the site of the band, we found, to our chagrin, that just as we had feared, the wall of the aorta embraced by the band was, in almost every instance, atrophied, being reduced in some cases to hardly more than a film in thickness. Notwithstanding this observation the experiments went on uninterruptedly, a new series being instituted with the hope that, with an improved technique and the employment of narrower and thinner bands, the walls of the arteries might retain their vitality, at least for a time sufficiently long to justify a second interference, and possibly the complete interruption of the blood current at a point just above the band. The width of the bands was reduced from 4 or 5 mm. to 2 or 3 mm., and the thickness from 32 and 33 degrees of fineness to beyond the highest numbers of our sheet metal scale, to what we term Nos. 37, 38, 39, and 40. On the carotids and femorals metal still thinner might perhaps be used. Bands so narrow and so very thin are easily rolled with the fingers. It is well to give the band approximately the proper curling before placing it on the artery. From the very first experiment we endeavored in each instance to roll the band as perfectly, as cylindrically, as possible, flattening of it being studiously guarded against for obvious reasons. Attempts to diminish the blood pressure very gradually and with accuracy are, of course, made futile by an imperfection in the rolling of the band. A flattening or imperfectly rolled band might, even if loosely applied, injure the intima and so cause thrombosis and completely interrupt the circulation. For these and other reasons silver wire, which was tried, was found impracticable. About ninety experiments were made on sixty-eight dogs. The technique of our operating rooms at The Johns Hopkins Hospital was observed in every particular and hence much time was consumed by the operations; but we are well repaid for the care exercised by the absence of wound infection. The buried, continuous, silver wire suture of the skin, and rubber gloves for operator and assistants seem invaluable in experimental surgery when wound infection must be avoided. We are greatly indebted to Messrs. Cowles, Faris, Haller, Lankford, and other fourth year students for their faithful assistance and interest and useful suggestions.

Summary.

(1) Thrombosis has not been observed in a single case. In a few of the specimens, however, proximal to the band, in the occluded artery, a little caruncle-like body, suggesting the substitution of a minute clot, has been present.

(2) Applied tightly enough to completely interrupt the circulation, the band has caused atrophy and sometimes complete absorption of the aortic wall; in such cases haemorrhage has invariably been prevented by the formation of connective tissue.

(3) With two or three exceptions there has been no evidence of adhesion of the folded intima *under the band;* aortic walls folded on themselves so snugly that, the band being still in place, water could not be forced through with a syringe, could easily be smoothed out and the full lumen reestablished on removal of the band.

(4) Less snugly, loosely, and very loosely applied bands may remain on the aorta, femorals and carotids for months without causing macroscopic injury to the walls of the artery. In experiments of this variety the band after, say, one hundred days, shimmers brightly under a normal looking peritonaeum, causing no visible reaction, and it may be as easily removed from the aortic wall as when originally applied. The probe point of a fine scissors passed into the lumen of the aorta and thus on through the band, dividing it and the aortic wall, reveals a perfectly normal looking intima and an aortic wall which, on gross section, evidences no change in texture and usually none in color.

We are encouraged to believe that there may be a place in surgery for the partially occluding band. Recently we have twice had occasion to use it on the human subject.

Case I.—*To the left common carotid was applied an aluminum band which almost occluded it.*—Even in this case slight head symptoms persisted for several months, making it seem likely that complete occlusion would have been followed by severe symptoms if not by death. We regretted that, in this case, the band was inadvertently rolled tighter than intended; it could, of course, have easily been removed and reapplied, but our notions being rather vague as to the precise amount of constriction which we desired and being unable to determine accurately the blood pressure distal to the band, we decided to let it remain and note the results.

Case II.—*A woman asphyxiated to unconsciousness by an aneurism of the arch of the aorta.*—She was restored to consciousness and temporary relief afforded by a tube passed into the right bronchus. The skiagraph seeming to indicate that the aneurism was chiefly on the left side of the sternum and the condition of the patient being so desperate, I decided, having watched her for nearly half a day, that she would live only a few hours

unless surgery could assist her. We exposed carefully and freely, without opening either pleural cavity, the heart, the arch of the aorta and the large vessels at the root of the neck, hoping possibly to be able to encircle the aortic arch with a band of metal between the origins of the innominate and left carotid arteries; but the aneurism involved the entire arch and thus defeated our very earnest efforts to carry out the plan. The patient succumbed on the operating table before we had entirely despaired of being able to do something for her relief, and while we were still endeavoring to make a path for the band.

The small arteries, the ligation of which endangers merely the life of the limb may prove as suitable for partial occlusion as the aorta (abdominal and thoracic) which has never been successfully ligated in man. Meagre as our knowledge of this subject is, I should probably feel it my duty to test the value of partial rather than resort to complete occlusion of the aorta, common carotid, popliteal and other arteries whose ligation is attended with great danger to life or limb.

The partial occlusion of arteries discloses a suggestive and, I believe, a promising field for investigation in physiology and experimental pathology.

The history of the subject will be considered in a subsequent article. Of particular interest to us is the discovery that Luigi Porta, about 1846, attempted partial occlusion of arteries by means of strips of diachylon plaster applied in a way similar to that described by Brewer, who so ingeniously and cleverly closes wounds of arteries by strapping them with an absorbable plaster.

THE RESULTS OF THE COMPLETE AND INCOMPLETE OCCLUSION OF THE ABDOMINAL AND THORACIC AORTAS BY METAL BANDS[1]

With the assistance of my house surgeon, Dr. W. F. M. Sowers, who most zealously aided me in making the experiments, and Dr. E. H. Richardson, a member of the surgical staff of The Johns Hopkins Hospital, during the past twelve months, I have been able to conduct experiments on the aortas of more than one hundred dogs and have noted particularly:

1. *The effects of occlusion,* partial and complete, immediate, mediate and ultimate on the blood pressure, general and local (above and below the band). The pressure below the band is lowered in proportion, roughly, to the amount of occlusion. The return of the pressure to approximately normal below the band is rapid, but varies greatly in the different dogs. For example, in one dog, a rise below the band of ten millimetres (Hg manometer) was noted in ten minutes; whereas, in another, two hours were required for a rise of fifteen millimetres. For the return of the normal pulse wave months may be required.

2. *The macroscopic and microscopic findings* in the arterial wall. (a) Partially occluding bands produced, as a rule, no macroscopic change in the aortic wall under the band, even after seven or eight months. (b) Under completely occluding bands the wall usually atrophied, and in the course of weeks or months was absorbed. (c) *When the lumen is almost but not quite occluded, complete occlusion may result spontaneously with the conversion of the arterial wall embraced by the band into a solid cylinder of living tissue. This may be considered the ideal closure of an artery,* and hitherto has probably not been achieved. Although this spontaneous secondary occlusion has occurred only thrice in the long series of experiments, it might, perhaps, if systematically tried for, be accomplished frequently, and ultimately the band might be so accurately applied that, unaided further by the surgeon, a partial occlusion would be likely to proceed to total occlusion.

[1] Abstract of remarks before the Section on Surgery and Anatomy of the American Medical Association, Boston, June 5-8, 1906. [Dr. Halsted prefaced his remarks with a brief historical sketch of the results of ligation of the abdominal aorta in animals and man and demonstrated an instrument and the method employed in the application of the metal (aluminum) bands.]

Tr. Surg. and Anat. Am. M. Ass., Chicago, 1906, 587-590.

Also: J. Am. M. Ass., Chicago, 1906, xlvii, 2147.

3. *The effects on the spinal cord* and its coverings. The study of the spinal cord was entrusted to Mr. P. K. Gilman (now Dr. Gilman and a member of my staff), whose trained eye discovered in a number of cases, about three months after operation, a deposit of extradural fat about the cord below the site of the aortic band. In three cases the production of fat was so great that it filled, seemingly under considerable tension, the vertebral canal. This is a phenomenal discovery and one which signifies much, whether on further investigation it be found that lesions in the spinal cord or simple anaemia of the particular extradural region is responsible for the deposition of fat. It is important to determine with precision the limitations of the fat deposit and to ascertain if regions at a distance, supplied by nerves derived from the affected cord-area, yield symmetrical masses of fat.

As to the practical value of the occlusion of blood vessels by the metal band, I have in mind the gradual occlusion of large arteries, particularly the aorta, abdominal and thoracic. A vessel partly closed by a nicely rolled band may subsequently be completely occluded either spontaneously (ideal result) or by the pressure of the fingers or of a forceps on the band. It is conceivable that in some instances this subsequent tightening of the band might be accomplished subcutaneously, but usually a second, though comparatively insignificant, operation would be required. Aortic aneurisms if situated too high for the subdiaphragmatic application of the band might be cured by a band on the thoracic aorta. To apply a band to the thoracic aorta is not difficult and may be executed rapidly without the excision of a rib. When it may be necessary to test the effect of blocking an artery before permanently occluding it, as in carotid, popliteal and high femoral ligations, the metal band might be desirable because (1) it serves the purpose of both clamp and ligature; (2) during the operation it may be safely removed if advisable, for the arterial wall is uninjured by it; (3) if too tightly rolled it may be removed at any time after the operation, even days thereafter, in case gangrene threatened or cerebral symptoms developed for, the arterial wall being uninjured, the normal lumen remains.

I have at present under observation a dog whose thoracic aorta has been experimentally occluded. The aluminum band was not rolled so tightly as completely to occlude the artery or to produce demonstrable weakness of the hind legs. The recovery from the operation was uneventful, but about three weeks thereafter paraplegia developed suddenly and, coincidentally, disappearance of the femoral pulse on both sides. I expect to find that complete occlusion of the thoracic aorta has been spontaneously accomplished, and in the manner above described. Partial occlusion, not becoming complete, might of itself occasionally cure an aneurism.

In the human subject I have partially occluded the innominate once and the common carotid four times, successfully, with the aluminum band. In a case of large popliteal aneurism I employed the metal band to occlude completely the femoral artery because this method enabled me particularly well to test the blood pressure during the gradual process of occlusion. In the case of a woman asphyxiated to unconsciousness by an aneurism of the aortic arch I exposed, carefully and freely and without puncturing either pleural cavity, the heart and arch of the aorta, hoping possibly to be able to encircle with a band the aortic arch between the regions of the innominate and left carotid arteries, but the aneurism so involved the entire arch as to defeat the earnest endeavor to execute the procedure.

I may assume that it is not necessary to remind this audience of the results which have attended ligation of the human aorta. The most successful of these operations was performed in 1899 by Dr. W. W. Keen, whose patient, the thirteenth case, lived forty-three days.

CLINICAL AND EXPERIMENTAL CONTRIBUTIONS TO THE SURGERY OF THE THORAX[1]

The Thoracic Aorta.—December 18, 1906, Dr. Halsted applied a partially occluding aluminum band to the thoracic aorta about 7 cm. above the diaphragm, with the hope of influencing the progress of and relieving the excruciating pain caused by a large aneurism of the upper abdominal aorta. A positive pressure box designed by Drs. Follis and Fisher was satisfactorily employed. Convalescence from the operation was without noteworthy incident. The pain, which had been almost agonizing before the operation, was so fully relieved that on the second day thereafter and for the fourteen following days 1/10 to 1/12 of a grain of morphine, given twice in twenty-four hours, sufficed to relieve the craving for the drug as well as the slight pain of which the patient complained. The chief postoperative disturbances were digestive. January 10, 1907, an aluminum band was applied to the abdominal aorta, below the aneurism and the inferior mesenteric artery, just tight enough to occlude the femoral pulse. From the second operation the patient recovered, also uneventfully. January 23d dysphagia developed, and a distinct pulsation was observed in the third and fourth intercostal spaces. January 28th patient died from intrathoracic rupture of the aneurism. The aortic wall under the bands, thoracic and abdominal, appeared normal. Interesting observations of the urine and blood pressures, in this and the following case, were made by Dr. Gatch and will be reported by him.

That there is reason for hope of cure in cases of aneurism of the abdominal aorta by partial constriction of this vessel, even when the band must be applied above the renal arteries, the following case would seem to indicate.

The Abdominal Aorta.—February 23, 1909, Dr. Halsted applied in the human subject an aluminum band to the abdominal aorta, between the superior mesenteric for an aortic aneurism extending from its bifurcation to the renal arteries. The aorta having been exposed, its isolation at the required spot, just above the almost vertical edge of the aneurism, was accomplished with great difficulty. The inferior mesenteric vein was tensely stretched along the left edge of the aorta at the site of election. The renal arteries below, the left renal vein in front, the superior mesenteric artery

[1] Presented at the American Surgical Association, Philadelphia, June 3-5, 1909. Tr. Am. Surg. Ass., Phila., 1909, xxvii, 111-115.

above, and the inferior mesenteric vein to the left, when separated in grid-iron form, exposed barely sufficient space on the aorta for the occupancy of a narrow metal band. The greatly emaciated patient was promptly relieved of the aneurismal pain by the operation. The tumor steadily decreased in size for five days. On March 1st, the sixth day after operation, the aneurism, which prior to operation projected and pulsated conspicuously, had disappeared to inspection, and on palpation the force of the pulsation seemed less than over the normal aorta above. The patient, a physician, aged fifty-three years, was on this and the preceding day, unable either to appreciate the presence of the aneurism by his sensations or to locate it by the sense of touch, and expressed the belief that he was cured. The following day a definite increase in the size of the aneurism and in the force of the pulsation was observed. In two days it was as large and in three or four days larger than before the application of the band. March 5th patient had a sudden onset of pain in the right iliac fossa and about the umbilicus, a chill, and a temperature of 103°. The rate of enlargement of the aneurism increasing, March 12th Dr. Finney wired the aneurism by his method with success as concerned the hardening of the aneurism; but it continued to grow with even greater rapidity. The patient, unable to take food, died April 11, 1909. At the autopsy the aneurism, larger than a cocoanut, was found to be remarkably well solidified in consequence of the wiring, except posteriorly and above. The band was in place and the tissues about it were quite normal in appearance. Ultimately a small psoas abscess which had softened the underlying vertebrae and the posterior wall of the overlying aneurism was discovered, and from it a fine sinus was traced exactly to the lower edge of the aluminum band on the aorta. The suppuration, the first in the annals of The Johns Hopkins Hospital in a clean abdominal case, was, in the opinion of Dr. Halsted, the cause of the sudden enlargement of the aneurism after its apparent disappearance. The aortic wall under the band was macroscopically normal notwithstanding the infection. The growth of the aneurism in the upward or centripetal direction had been abruptly held in check by the band, which at its upper edge was in contact with the superior mesenteric artery, and at its lower with both renal arteries. Distressing as was the outcome in this instance, one finds much encouragement in this case for continuing the endeavor to cure aneurism of the aorta by partial occlusion of this vessel after the manner described.

The Lungs.—In the experimental surgery of the lungs upon dogs Dr. Halsted, assisted always by Dr. Gatch and Messrs. Emmert and Webb, concerned himself chiefly with the bronchi and vessels at the root of the lungs and the various lobes. Occlusion of the main, the primary, and secondary divisions of the bronchi was practised, various methods and almost

all degrees of occlusion being tested. The lung was only occasionally excised. From complete occlusion of a bronchus by ligature or metal band there resulted atalectasis, with no apparent impairment of the health of the dog. Occlusions by the metal band of primary or secondary bronchi, so nearly complete as hardly to permit the passage of a very fine knitting needle and as to cause circumscribed areas of atalectasis, in no instance gave rise to pulmonary emphysema or to definite dilatation of a bronchus. Under completely or partially obliterating bands the mucous lining of the bronchus under the band was always found unaffected even after several weeks. In no instance had the experimenters been able to crush the bronchial wall with the encircling band, and hence in no case had obliteration of the bronchus occurred by this method. Even ligatures of black silk which completely occluded the bronchus did not permanently obliterate it unless the mucosa were crushed. Particularly secure obliteration was accomplished by bisection of the bronchus, careful excision with the scalpel of its mucosa, and the approximation of the raw surfaces by a running suture of fine black silk.[2] By this method the bronchus may be converted into a solid fibrous cord. Inversion of the bronchus was abandoned in the two cases in which it was attempted because the bronchus seemed too short for nice adjustment.

Ligation of the pulmonary arteries or veins to the lobes of one side produced no visible change in the color or consistence of the lobes during the period of operation.[3] About a week later, however, in the two observations of this kind, a slight change in the color and apparently in the consistence of the lobes so treated was noted. They were less pink, a little grayer, and possibly a little less aërated than the other lobes. Attempts to inoculate the lungs of dogs with tuberculosis were uniformly and rather unexpectedly successful (3 cases). Ligation of the pulmonary vessels, undertaken with the idea that possibly the infection might thereby be intensified or modified, was without demonstrable influence.

The Technique.—In addition to the usual precautions against infection, such as gloves and masks, and unusual care in the shaving and preparation of the skin of the dogs, a thin covering of an alcoholic solution of shellac was applied to the shaved area over a single layer of gauze. Some ten or more years ago Dr. Halsted experimented with shellac solutions as covering for the hands of the operator, with the idea that possibly under certain circumstances the rubber gloves, which since 1890 had been used in his clinic at The Johns Hopkins Hospital, might be dispensed with, but he soon abandoned the notion that a film of shellac or other substance applied to the

[2] After the manner devised by Dr. Halsted for the closure of the duct of the gallbladder.

[3] These observations confirm those of Lichtheim, Welch, and subsequent observers.

hands might replace the gloves. For the skin of the human patient the shellac has since then been occasionally but not enthusiastically employed. Very small skin and pleural incisions were made, the ribs being forcibly separated with the fingers and then with the retractor. The ribs were brought together with silver wire, and the soft parts sewed with fine black silk. All sutures were buried except the so-designated *epithelial stitch,* elsewhere described, which rubs away without attention from the surgeon, or may be ripped off like a plaster from the surface. This stitch, which to human surgery has only occasional application, is useful in the surgery of dogs.

In twenty-one consecutive thoracotomies there was only one primary infection of the thorax, and in this case no masks were used and a droplet contamination of the wound was noted in the account of the operation written immediately. Positive pressure was employed in all of the experiments, and by means of a very simple, effective, and very cheap apparatus devised by Dr. Gatch. The cost of the box was ten dollars. It was exhibited to the Association.

PARTIAL OCCLUSION OF LARGE ARTERIES BY ALUMINUM BANDS[1]

The paper of Dr. Matas has interested me exceedingly. I regret that I had not known of the Moszkowicz test in time to make use of it in a case operated upon at The Johns Hopkins Hospital last winter. In the removal of a cystic sarcoma from the popliteal space it was necessary to excise almost the entire popliteal artery and vein, and what, at the time, seemed to be the entire sciatic nerve. Inasmuch as gangrene has almost invariably supervened upon excision so complete of both popliteal vessels, about ten inches of the internal saphenous vein of the opposite thigh was transplanted by the Carrel method; its upper end was sutured to the proximal stump of the popliteal artery in Hunter's canal, and its lower end to the distal stump of the popliteal vein. Blood circulated freely through the transplanted piece for about thirty minutes; then thrombosis of its lower end occurred. The temperature of the foot on the operated side was higher than that of the other foot for several days. Gangrene did not occur, notwithstanding the removal of the popliteal artery and vein down almost to the point of division of the former.

As to the relative ease with which the flattened bands recommended by Dr. Matas can be made use of, the idea evidently prevails that the application of the rolled bands with the band-curler is difficult. One must, of course, have some notion as to the thickness, width, and length of the metal strip, which may, in a given case, be employed to the best advantage. With suitable instruction one might, I believe, after practising an hour or two on an animal, become quite proficient, and be able to apply the bands properly rolled in a cylindrical form as readily, if not indeed as quickly, as the flattened strips.

We learned in the course of experiments made with the object of preserving the integrity of the wall of the artery, that accurate rolling of the band, viz., with preservation of cylindrical form is essential. When the band is properly rolled the wall of the artery is so infolded that pressure on no point of the arterial wall is excessive, and hence perceptible thinning and weakening of the wall does not occur, at least for many months, unless the

[1] Remarks in discussion of Dr. Rudolph Matas' paper, "Some of the problems related to the surgery of the vascular system: testing the efficiency of the collateral circulation as a preliminary to the occlusion of the great surgical arteries." American Surgical Association, Washington, D. C., May 3-5, 1910.

Tr. Am. Surg. Ass., Phila., 1910, xxviii, 49-52.

constriction has been made so tight as to shut off the arterial flow within the lumen of the banded vessel, and presumably, also, the blood current in the vasa vasorum. Occasionally the compression has been accomplished with such nicety that the constricted portion of the artery, the part circumscribed by the metal, became converted into a fibrous band. It need hardly be emphasized that it is desirable that the vitality of the arterial wall should not be impaired whether the band is permanently or temporarily applied.

I am pleased to be able to report two cases of probable cure of aneurism—one subclavian and one external iliac—by partial obliteration, in the former case of the subclavian, and in the latter of the common iliac artery.

I am not sure that aneurisms curable by simple ligation of an artery might not be cured as surely and promptly by incomplete occlusion of the vessel—by an occlusion sufficient to stop the pulsation in the constricted artery, but not enough to arrest entirely the flow of blood through the almost obliterated portion.

Before making more definite pronouncement on this matter further experiments must be made in testing on normal vessels the rapidity of the return circulation under the two conditions.

Writers on the subject of ligation of the common iliac artery are agreed that this operation is followed by gangrene in from 20 per cent to 33 per cent of the cases. Inasmuch as gangrene has never resulted from ligation of the abdominal aorta in the human subject, not in any one of the many instances in which I have occluded this vessel in dogs, it is difficult to believe that it is so likely to occur after ligation of one common iliac artery. And, having studied carefully the histories of the cases in which gangrene is reported to have occurred after ligation of a common iliac artery, I find that in not a single instance is the gangrene to be attributed to the ligation of this vessel alone. In every case other important vessels concerned in the establishment of the anastomotic circulation were ligated; in some cases almost every named vessel which could contribute to the restoration of the circulation was ligated, and in many of the cases wound infection was an additional and occasionally very considerable complication.

I regret that I have as yet no case to report of cure of an aortic aneurism, but I find great encouragement to further attempts from the result of the only case suitable for the application of a band to the abdominal aorta which it has been my fortune to treat. In this case the aneurism was spheroidal and about 10 or 11 cm. in diameter. It was found on operation to extend to the renal arteries. Very great difficulty was experienced in exposing enough of the aorta between the renal arteries and the coeliac axis to permit of the passing under it of a tape as a preliminary step in the application of the metal band. The inferior mesenteric vein was especially

in the way, traversing the aorta from right to left at the very point at which the band had to be applied. The renal vessels, arteries and veins, stretched across our little field and had to be drawn downward. The coeliac axis was above; the vena cava, which overlay the aneurism and a part of the aorta between the renal vessels and the coeliac axis, could be dislocated to the right. We were working, consequently, in a little gridiron-like square, rigidly bounded on all sides by large blood vessels, each of vital importance. This space, stretched to its utmost, was barely large enough to admit ultimately two fingers. The aorta leading to the aneurism, which proved to be of the sacculated variety, lay very deep behind the almost vertical upper edge of the tumor. For a considerable time the passage of a ligature at this, the only feasible point, seemed almost beyond accomplishment. When, after about one and a half hours, we had succeeded in passing the first tape around the aorta at the point of election, just above the renal arteries and close to the aneurism, the placing of the band was accomplished with relatively little difficulty. It was, however, necessary to remove the glove from my left hand to make possible the rolling of the band, so small was the space and so deep the aorta.

The greatly emaciated patient recovered promptly and without distress from the immediate effects of the operation. The following day he expressed himself as greatly relieved of the pain from which he had suffered for many months, and as having desire for food. The aneurism, twenty-four hours after the operation, seemed to be smaller. In forty-eight hours it was undoubtedly smaller, and in five days it had so greatly diminished in size as to be almost undemonstrable. Then, when our hopes were at the highest point, the patient had a chill and temperature of about 40° C. On the following day, again a chill and high temperature. There were no further chills nor elevations of temperature, but the aneurism enlarged with such rapidity that forty-eight hours after the first chill it was perhaps as large as before the operation. The rate of enlargement increased with the passage of days. Dr. Finney was asked to wire the aneurism. This he successfully accomplished, but the growth of the aneurism was apparently not influenced. Its consistence was, however, changed. It became very hard at first, in front, but the aneurism was evidently expanding from behind. Then it showed lateral expansions and took on for the first time a somewhat lobulated shape, being softer in certain portions. In a few weeks the patient died, chiefly of starvation. The autopsy revealed what was the probable cause of the failure of the operation to cure the aneurism, but not until the abdominal contents, including the aneurism, had been removed. A small psoas abscess was then discovered, containing perhaps three or four ounces of very thin seropus. This abscess lay directly behind the aneurism and led by a very

small sinus to the site of the band on the aorta. The posterior surface of the aneurism had evidently been softened by the abscess and, hence, deprived of its ability to resist the force of the circulation, had rapidly distended. About the coiled wire introduced by Dr. Finney there was a large, very firm, and more or less organized clot. It seemed as if the wiring alone might have cured the aneurism had it not been for the inflammatory softening of the wall. Clearly the abscess had its origin at the site of the band, and the infection, predisposed to by the greatly enfeebled condition of our patient, had its immediate cause in the local inoculation, which, in turn, was to be explained by the fact that the glove had to be removed and the band to be rolled by the bare, although carefully disinfected, fingers.

This case, which I hope to publish later in detail, gives us great encouragement. Had it not been for the infection the aneurism would, we think, probably have been cured. The facts that the aneurism gradually diminished in size until on the fifth day it was hardly demonstrable, and reappeared synchronously with the manifestations of infection justify the inference that the abscess formation was responsible for the result. It was to me of particular interest to note that the aortic wall at the site of the band was intact notwithstanding the infection in the tissues about it.

It would gratify me very much to have opportunities to test again the effect of partial occlusion of the abdominal aorta in aneurism of the vessel below the renal arteries and in aneurism of the common iliac artery.

The partial occlusion of arteries by the metal band has, I think, opened a field for investigation in physiology and experimental pathology as well as in surgery.

THE EFFECT OF LIGATION OF THE COMMON ILIAC ARTERY ON THE CIRCULATION AND FUNCTION OF THE LOWER EXTREMITY

REPORT OF A CURE OF ILIO-FEMORAL ANEURISM BY THE APPLICATION OF AN ALUMINUM BAND TO THAT VESSEL[1]

The purpose of this paper is not so much to publish a case in which a cure of ilio-femoral aneurism was accomplished by the application to the common iliac artery of a barely or completely occluding aluminum band as to consider the reasons for the view which prevails that ligation of this artery is an exceedingly dangerous procedure and likely to be followed by gangrene, and to determine, if possible, the ultimate result of this operation so far as usefulness of the limb is concerned.

I have endeavored to assemble all the cases of ligation of the common iliac artery reported since 1880, accepting, in order to avoid confusion, this arbitrary date, proposed by Dreist[2] as being within the antiseptic period. Although antiseptic surgery was not universally practised until after 1890 in the United States and Great Britain, the countries which have contributed most to the surgery of the common iliac and of the other large arteries, infection has not played part enough in the cases here collected to obscure the factors responsible for the results and thus prevent the drawing of deductions concerning the matters which it is the particular purpose of this paper to consider.

In the years from 1880 to 1912, the common iliac artery has been ligated at least 30 times, or about once a year, for the control of haemorrhage and the cure of aneurism.

Undoubtedly the reports of some have been overlooked by me and the number of unpublished cases may be considerable. The Index Medicus has been of the greatest assistance in my search, not one of the cases found in other medical bibliographies having been overlooked by this indispensable work. Only three of the published cases of my list are not to be found in the admirably arranged and marvellously accurate index of the Index Medi-

[1] Presented at the American Surgical Association, Montreal, Canada, May 29-31, 1912.

Johns Hopkins Hosp. Bull., Balt., 1912, xxiii, 191-220. (Reprinted.)

Also: Tr. Am. Surg. Ass., Phila., 1912, xxx, 196-286.

[2] Deutsche Ztschr. f. Chir., 1903, lxxi, Heft 1, 26.

cus and there is good excuse for the omission of these, there being no titular indication of their existence.

Thanks to the courtesy of Dr. McCaw, the library at Washington of the Surgeon-General has been at my disposition, and not one of the desired articles has been wanting from its shelves. This privilege has enabled me to make an abstract from the original article in every case.

The common iliac artery was ligated for the first time July 27, 1812,[3] *just one hundred years ago,* and in this period it has been tied about 100 times.

The original operation was performed for the arrest of haemorrhage by William Gibson,[4] at that time Professor of Surgery in the University of Maryland, Baltimore. The patient was a male, aet. 38. A musket ball entering the left side of the abdomen passed through the intestine, opened the left common iliac artery and lodged in the sacrum. Peritonitis developed promptly. On the ninth day a severe haemorrhage occurred. From this time, until the death of the patient, on the fifteenth day after operation, there were repeated haemorrhages.

Valentine Mott was the first deliberately to tie the common iliac artery. The operation, undertaken for the cure of ilio-femoral aneurism, was successful. The story of the case as related by him is impressive and gives one some idea of the courage, skill, sagacity and resourcefulness of this remarkable man.

The following passages are quoted from Dr. Mott's report:[5]

"On the 15th of March, 1827, I was requested to visit a patient with Dr. Osborn (of Westfield, New Jersey, about twenty-five miles distant from New York) whom we found laboring under a large aneurism of the right external iliac artery.

"Israel Crane, aged 33 years, says that about the middle of January he felt some pain about the lower part of the belly, which he attributed to a fall received during the winter.

"It, however, was not until a fortnight since, that he perceived any tumor about the lower part of the abdomen. Upon examination, the abdomen on the right side was considerably enlarged from about the crural arch, as high as the umbilicus. When the hand was applied to the parietes of the abdomen a pulsation was felt and rendered visible to some distance. To the touch, the tumor beat violently and appeared to contain only fluid blood. It commenced a little above Poupart's ligament and reached, judging by

[3] Am. M. Recorder, 1820, iii, 185.

[4] Dr. Gibson performed this operation at the age of twenty-four. It was due to his efforts that, the previous year, the Medical School in which he held the Chair of Surgery was founded.

[5] Successful Ligation of the Common Iliac Artery. By Valentine Mott, M.D., Professor of Surgery, N. Y. Am. J. M. Sc., 1827, i, 156.

the touch, from without near the navel—inwards, almost to the linea alba—outwards and backwards filling up all the concavity of the ileum, and reaching beyond the posterior superior spinous process of that bone.

"The rapid increase of this aneurismal tumor occasioned, as the countenance of our patient indicated, the most extreme agony. His sufferings were at times so great that his screams could be heard at a distance from the house. He had been bled several times, taken light food, and was kept constantly under the influence of opium. He was now informed of the serious nature of his case, and that without an operation very little chance of his life remained. With great composure he immediately consented to whatever would give him the best prospect of saving his life.

"From the extent and situation of the tumor, he was apprised of the uncertain nature of the operation, as well as the difficulty of performing it, and indeed that it would require an artery to be tied, which never had been operated upon for aneurism.

"With these views of his situation, he cheerfully submitted to be placed upon a table of suitable height in a room which was well lighted.

"The pubes and groin of the right side being shaved, an incision was commenced just above the external abdominal ring, and carried in a semicircular direction half an inch above Poupart's ligament, until it terminated a little beyond the anterior superior spinous process of the ilium, making in extent about five inches.

"The integuments and superficial fascia were now divided, which exposed the tendinous part of the external oblique muscle, upon cutting which in the whole course of the incision, the muscular fibers of the internal oblique were exposed; the fibers of which were cautiously raised with the forceps and cut from the upper edge of Poupart's ligament. This exposed the spermatic cord, the cellular covering of which was now raised with the forceps, and divided to an extent sufficient to admit the forefinger of the left hand to pass upon the cord into the internal abdominal ring. The finger serving now as a director, enabled me to divide the internal oblique and transversalis muscles to the extent of the external incision, while it protected the peritonaeum. In the division of the last mentioned muscles outwardly, the circumflexa ilii artery was cut through, and it yielded for a few minutes a smart bleeding. This, with a smaller artery upon the surface of the internal oblique muscle, between the rings, and one in the integuments were all that required ligatures.

"With the tumor beating furiously underneath, I now attempted to raise the peritonaeum from it, which we found difficult and dangerous, as it was adherent to it in every direction. By degrees we separated it with great caution from the aneurismal tumor, which now bulged up very much into the incision. But we soon found that the external incision did not enable us to arrive at more than half the extent of the tumor upwards. It was, therefore, extended upwards and backwards about half an inch within the ilium, to the distance of three inches, making a wound in all about eight inches in length.

"The separation of the peritonaeum was now continued, until the fingers arrived at the upper part of the tumor, which was found to terminate at the going off of the internal iliac artery. The common iliac was next examined

by passing the fingers upon the promontory of the sacrum, and to the touch appearing to be sound, we determined to place our ligature upon it about half way between the aneurism and the aorta, with a view to allow length of vessel enough on each side of it to be united by the adhesive process.

"The great current of blood through the aorta made it necessary to allow as much of the primitive iliac to remain between it and the ligature as possible, and the probable disease of the artery higher than the aneurism required that it should not be too low down. The depth of this wound, the size of the aneurism, and the pressure of the intestines downwards by the efforts to bear pain, made it almost impossible to see the vessel we wished to tie. By the aid of curved spatulas, such as I used in my operation upon the innominata, together with a thin, smooth piece of board, about three inches wide, prepared at the time, we succeeded in keeping up the peritonaeal mass, and getting a distinct view of the arteria iliaca communis, on the side of the sacro-vertebral promontory. This required great effort on our part, and could only be continued for a few seconds. The difficulty was greatly augmented by the elevation of the aneurismal tumor, and the interception it gave to the admission of light.

"When we elevated the pelvis, the tumor obstructed our sight; when we depressed it, the crowding down of the intestines presented another difficulty.

"Introducing my right hand now behind the peritonaeum, the artery was denuded with the nail of the forefinger, and the needle conveying the ligature was introduced from within outwards, guided by the forefinger of the left hand in order to avoid injuring the vein. The ligature was very readily passed underneath the artery, but considerable difficulty was experienced in hooking the eye of the needle, from the great depth of the wound and the impossibility of seeing it. The distance of the artery from the wound was the whole length of my aneurismal needle.

"After drawing the ligature under the artery, we succeeded, by the aid of our spatulas and board, in getting a fair view of it, and were satisfied that it was fairly under the primitive iliac, a little below the bifurcation of the aorta. It was now tied; the knots were readily conveyed up to the artery by the forefingers; all pulsation in the tumor instantly ceased. The ligature upon the artery was very little below a point opposite the umbilicus.

"The operation lasted rather less than one hour.

"In less than one hour from the operation, considerable reaction of the heart and arteries took place; he felt, as he stated, altogether relieved from the excruciating agony he had suffered since the aneurism commenced. The whole limb had now recovered its natural temperature.

"*March 16th.*—The day after the operation; pulse eighty; skin moist; limb warm as the other; complains of some pain at the ligature; ordered a purgative of neutral salts.

"*March 17th and 18th.*—There was considerable pain in the limb.

"*April 8th.*—There are no disagreeable appearances whatever. He appears to be doing remarkably well; has been bled once since the last report; takes a purgative every other day, and an opiate every night; pulse as in health; no pain; says he is entirely comfortable; wound dressed with dry lint.

"*April 16th.*—Has improved rapidly since the last report. Two days after the ligature came away he very imprudently got out of bed without experiencing any difficulty, except weakness. Rode out today; wound perfectly healed.

"*April 30th.*—Is perfectly restored to health; has a little stoop in his walk, which he says is occasioned by the external cicatrix. Leg is not yet of its full size, nor quite so strong as the other. From the period of the operation, to the recovery of our patient, he did not appear to suffer more pain, or to have more unpleasant symptoms, than would ordinarily take place in a flesh wound of equal extent.

"*May 29th.*—My patient visited me today, having come twenty-five miles; he was so much improved in health that I did not recognize him. Examined the cicatrix and found it perfectly sound; could not discover any remains of aneurismal tumor; *felt the epigastric artery much enlarged and beating strongly* (italics mine), and a feeble, though distinct pulsation in the femoral artery immediately below the crural arch. The leg has its natural temperature and feeling, and he says it is as strong as the other.

"The gratification his visit afforded me is not to be imagined, save by those who have been placed under similar circumstances. The perfect success of so important and novel an operation, with the entire restoration of the patient's health, was a rich reward for the anxiety I experienced in the case, and in a measure compensated for the unexpected failure of my operation on the arteria innominata.

"New York, 25 Park Place, October 15, 1827."

It is interesting to note that Dr. Mott raised the pelvis, just as we do today, with the object of having the abdominal contents gravitate towards the thorax. Being without artificial illumination or means of reflecting the daylight into the wound, he had to abandon this useful, and for us today, quite indispensable measure because with the pelvis elevated, the aneurismal tumor obstructed the view.

In 1853, Prof. Uhde, of Braunschweig, tabulated 17 cases of ligation of the common iliac artery performed to the year 1850 and reported in full detail a case in which he tied this vessel for aneurism of the gluteal artery. The article is illustrated with interesting wood-cuts depicting the conditions found by him at the autopsy of his patient. Uhde tabulated also, in this paper, the ligations, to 1852, of various arteries for the cure of gluteal aneurism.

Of the statistical papers on the subject of ligation of the common iliac artery the classic one of Stephen Smith,[6] published in 1860, is especially important.

[6] A Statistical Examination of the Operation of Deligation of the Primitive Iliac Artery, embracing the Histories (in abstract) of Thirty-Two Cases, By Stephen Smith, M. D., Surgeon to Bellevue Hospital, New York. Am. J. M. Sc., 1860, n. s. xl. 18

It is a tale of woe that Dr. Smith had to relate, tragic for the patient and for the surgeon; but hardly more pitiful than is to be found in the history of the operation as it has been performed in our modern antiseptic and aseptic times.

Stephen Smith collected 31 cases of ligation of the common iliac artery and reported an additional case of his own. In the 32 years from 1829 to 1859, 32[7] ligations of this artery were made and this average of one a year has been approximately maintained to the present time.

In the following table Dr. Smith has arranged the cases in chronological order (*l. c.*, p. 19).

No.	Date of operation	Operator	Result
1	July 27, 1812	Gibson, of Philadelphia	Died
2	March 15, 1827	Mott, of New York	Cured
3	July 18, 1828	Crampton, of Dublin	Died
4	December 1, 1829	Liston, of Edinburg	Died
5	August 24, 1833	Guthrie, of London	Cured
6	April 1836	Stevens, of New York	Died
7	May 26, 1837	Salomon, of St. Petersburg	Cured
8	1837	Garviso, of Monte Video	Died
9	June 8, 1838	Syme, of Edinburgh	Died
10	November 29, 1838	Pirogoff, of Dorpat	Died
11	April 10, 1839	Bushe, of New York	Died
12	February 22, 1840	Deguise, of Paris	Cured
13	August 26, 1840	Post, of New York	Died
14	August 29, 1842	Peace, of Philadelphia	Cured
15	December 3, 1843	Hey, of New York	Cured
16	1843	Garviso, of Monte Video	Cured
17	January 27, 1845	Stanley, of London	Died
18	June 3, 1847	Lyon, of Glasgow	Died
19	September 19, 1850	Chassaignac, of Paris	Died
20	December 29, 1851	Jones, of Liverpool	Died
21	January 1852	Moore, of London	Died
22	March 27, 1852	Wedderburn, of New Orleans	Died
23	October 7, 1852	Uhde, of Braunschweig	Died
24	November 1853	Van Buren, of New York	Died
25	March 20, 1857	Edwards, of Edinburgh	Died
26	March 26, 1857	Holt, of Georgia	Died
27	July 15, 1857	Meier, of New York	Died
28	July 3, 1858	Parker, of New York	Died
29	July 6, 1858	Buck, of New York	Died
30	October 6, 1858	Stephen Smith, of New York	Died
31	January 26, 1859	Stone, of New Orleans	Died
32		Goldsmith, Louisville	Died

[7] The date of the 32d operation by Middleton Goldsmith was not obtainable, but as Prof. Goldsmith reported it in February, 1860 (Louisville Medical Journal), the operation was presumably performed in 1859, or earlier.

"The indications," Dr. Smith writes, "which have thus far led to the deligation of the primitive iliac artery may be divided as follows:

"I. For the arrest of haemorrhage.

"II. For the cure of aneurism.

"III. For the cure of pulsating tumors, which proved to be malignant growths.

"IV. For the prevention of haemorrhage in the removal of a morbid growth."

In Group I are eleven cases. Ten of these died; nine from haemorrhage, primary (five), or secondary (four); one from peritonitis. Dr. Smith contrasts the mortality from ligation of the primitive iliac artery for the arrest of haemorrhage (approximately 91 per cent) with that following the same operation performed 14 times upon the external iliac artery for the same causes (21½ per cent) and makes this comment "a proper appreciation of the circumstances under which the primitive iliac artery has been tied for the arrest of haemorrhage will lead the discriminating surgeon, notwithstanding the excessive mortality that has thus far attended its performance, to accord to this operation an important place among the resources of his art."

In Group II (for the cure of aneurism) there are 15 cases. Five of these recovered; ten died; in two the result was unknown. This group has the greatest percentage of recovery from the operation and it is noteworthy that in at least one, Peace's, of the non-fatal cases, ligation of the common iliac artery did not suffice to cure permanently the aneurism which returned about 14 months later, ruptured and caused the death of the patient. In one of the recovered cases, Salomon's, gangrene ensued as result of the ligation. In this instance, a gangrenous eschar formed on the foot on the third day after operation, and "subsequently others appeared," but "convalescence was complete at the end of two months." This patient died ten months after the operation from an abscess below Poupart's ligament on the operated side.

Gangrene was the cause of death in two of the fatal cases, but in one of these, Syme's, it was present before operation.

Dr. Smith makes the following comment in considering the results of the operation of deligation of the common iliac artery for aneurism, as compared with the same operation upon the external iliac:

"In ninety-five cases, which I have examined, of ligation of the latter (external iliac) artery for aneurism, sixty-nine recovered and twenty-six died, being a mortality of about 27 per cent, or less than half the mortality of the same operation for the same disease when performed upon the common trunk. The cause of death in eleven cases, or nearly one half, of ligation of the external iliac for aneurism was mortification of the limb,

presenting a striking contrast with the same operation upon the primitive iliac in which there was but one instance in eight cases."

Group III. *Deligation of the common iliac for malignant tumors simulating aneurism.* It is noteworthy that in all four of the cases in this group the pulsating neoplasm was mistaken for aneurism. Mr. Astley Cooper who saw, in consultation, Mr. Guthrie's case expressed himself as positive that it was an aneurism.

In Group IV are two unclassified cases. The second of these, Chassaignac's, was, as Dr. Smith says, one of the most remarkable of the series. This eminent surgeon operated in a most brilliant manner for the cure of a large encephaloid tumor of the internal and superior aspect of the thigh, extending to the foramen ovale, and after ligation of the common iliac artery, the tumor was removed, "with scarcely the appearance of blood." The entire operation, performed under chloroform, lasted only half an hour.

Surgeons of the present day would be entertained by the perusal of the comments which Chassaignac's report of the case called forth, at a meeting of the *Société de Chirurgie.*[8] Dr. Smith gives an abstract of the discussion. Larrey, Robert and Forget condemned the operation in unqualified terms, Larrey blaming the operator for attempting so considerable an operation without previous consultation with his colleagues. Gosselin and Maisonneuve sustained Chassaignac.

In the 32 cases the extraperitonaeal incision was employed by all the operators with the exception of Gibson, Garviso, Post and Goldsmith. Of the nine cases in which the peritonaeal cavity was opened, either accidentally or intentionally, only two acquired peritonitis, and in both of these haemorrhage was an associated cause of death.

Another paper of importance on the subject of ligation of the common iliac artery and almost equal in statistical value to Stephen Smith's, is by Kümmel,[9] assistant at that time (1884) of Prof. Schede in the Allegemeines Krankenhaus zu Hamburg, and at present Surgical Director of the Eppendorf Hospital, Hamburg, which is so well known to surgeons throughout the world. To the 32 cases of Stephen Smith, Kümmel adds 30, collected from the 24 years between 1860 and 1884, an average of one-quarter of a case per year in excess of the record of the first 32 years in the history of the ligation of this artery.

With one or two exceptions, the complications which have led to the performance of this operation have been of grave import. In Groups III[10] and

[8] Bull. Soc. de chir. de Par. Paris, 1851.

[9] Kümmel, Arch. f. klin. Chir., 1884, xxx, 65.

[10] Group III. Ligations of the common iliac for the cure of pulsating, malignant growths.

IV[11] of Stephen Smith they are obviously of such nature as to make the cases comprised in these groups useless for the purpose of this study.

We shall consider, therefore, only cases which have been operated upon for the control of haemorrhage (Group I), or the cure of aneurism (Group II).

ABSTRACTS OF CASES FROM 1880 TO 1912

1. (Group I.) O'Grady, E. S. *Ligation of the left common and internal iliac arteries to arrest haemorrhage in a case of varicose aneurism for the cure of which the femoral artery had been ligated nine months previously. Death in about seven hours.* (The Medical Press and Circular, Dublin, 1880, July 28th, p. 71.)

Male, aet. 28. At the age of 13, patient clapped his thighs together to catch a shoemaker's knife. The sharp knife "transfixed the long saphenous vein and penetrated the femoral artery." Since the accident he had required surgical assistance at various times. With the aid of rest and the habitual use of an elastic bandage he had managed to earn a living. A pulsating tumor had formed "in the anterior and inner region of the middle of the left thigh." When examined by Mr. O'Grady (presumably in November, 1879), this tumor was as large as a cocoanut, and very prominent. From its lower part, there projected two hemispherical nodules as large as walnuts. The tissue intervening between these and the pulsating finger was so thin that it seemed as if the pulsating tumor might burst at any moment. Pressure on the femoral artery above stopped the pulsation. The long saphenous vein, dilated to the size of a man's thumb, "traversed and was imbedded in the mass." "There were enormously large knots of dilated and tortuous veins behind the knee and down the leg." A bruit was distinctly audible to bystanders and could be loudly heard over the heart.

Operation.—(November ?, 1879.) Two days after admission to the Mercer's Hospital, Dublin, the superficial femoral, cut down upon, was found to be as large as "a large man's middle finger"; its coats were "thin and unhealthy looking." The vessel was ligated with carbolized catgut in two places and cut between, the upper ligature being about one inch below the origin of the profunda artery. Each of the divided ends was again tied with a ligature of the same material. The wound was loosely closed with two interrupted sutures and covered with lint moistened in carbolized oil. The limb was wrapped in flannel bandages and surrounded by hot jars. Three hours after the operation the foot and leg were found to be very cold. The following morning they became warmer. The tumor was quite solid. Three days later the wound and parts about it were considerably inflamed, but there was no return of the pulsation or thrill. The latter lessened in intensity, "soon" returned, however, in the long saphenous vein which "stood out large and distended." Attempts, continued for some weeks, to bring about obliteration of this vein by pressure with padded corks proved ineffectual.

[11] Group IV. For the prevention of haemorrhage in the removal of a morbid growth.

"Sixty-six days after the deligation an aqueous solution of perchloride of iron was injected into a carefully insulated portion of the saphenous vein, the region selected being the central two inches where it crossed the tumor." Ten days later the same procedure was repeated without the desired result. But a week later a like injection, made lower down into the vein, was followed by a satisfactory local reaction, which in two days had sprung up and down the vein and "thoroughly coagulated its contents for its entire length."

One hundred and forty-eight days after the operation the patient left the hospital, his departure having been delayed by "recurrent attacks of more or less severe inflammation of the glands of the groin." The vein remained obliterated, and the aneurism was slowly getting smaller. July 5th, nine months after the deligation of the femoral artery, the patient returned to the hospital because there had been slight bleeding from the cicatrix. He reported that there had been occasional attacks of inflammation in the groin, and that from a particular spot in the cicatrix there would be discharged, every now and then, a drop or two of thin matter.

Examination.—The right groin and the abdomen to the ribs were swollen and tender and reddened with an erysipelatous blush. There was pulsation in "the stump of the femoral," but the swollen condition of the parts precluded the possibility of recognizing with certainty "how far any fresh aneurism formation might be present."

"On the night of the 8th, it could be determined that an aneurism had formed on the stump of the femoral, and was rapidly increasing in size."

July 9th.—At 7.45 a. m., "a terrible gush of arterial haemorrhage occurred," which, "though arrested 'on the moment,' left the patient blanched and prostrate."

Two hours later, the patient having rallied a little, the external iliac artery was cut down upon through matted tissues and adherent glands, but the vessel, found to be enormously enlarged, could not be isolated. So the incision was prolonged to the tip of the twelfth rib. The external iliac artery was followed up. It was tortuous and "as big as a sausage," "resembling a coil of intestine." The internal iliac, "atrophied rather than enlarged," was ligated with catgut and the common iliac artery as well.

The patient rallied and complained of great pain along the front of the tibia.

Seven hours later, becoming suddenly pulseless, he died.

Under difficult conditions a local examination was effected. There had been no further bleeding, and nothing was found to account for the sudden demise. "*The external iliac much exceeded the abdominal aorta in size;* it was a marvel how such a river of blood was controlled promptly enough to prevent immediate death." The long saphenous vein was atrophied and impervious.

2. (Group II.) Richter, C. M. *Ligation of the right common iliac for huge aneurism of the external iliac artery. Gangrene before operation.* (Max Richter, Pacific Medical and Surgical Journal, 1880-1881, p. 505.)

Male, aet. 30. Admitted to the German Hospital, San Francisco (?), January (?), 1881. "Rheumatic" pain in right inguinal region six and one-half months before admission.

Examination.—An irregular tumor the size of a child's head occupied the right hypogastrium. Pulsation not discernible. On auscultation a remote bruit could be heard. Arterial blood was aspirated with a hypodermic syringe. The right leg was oedematous, and its circumference about twice that of the other. Sensibility normal. Motility unimpaired. Patient was very anaemic, suffered from dyspepsia and constipation and from severe pains in the right leg and sacral region, which recurred every morning. The proposition to ligate the common iliac was not acceded to by the patient for several weeks. The tumor meanwhile increased in size, the pains became more severe, and finally intolerable and uncontrollable by morphia. Power of motion in the leg became lost and signs of gangrene appeared. Finally the patient consented to the operation.

February 19th.—The right common iliac was ligated by Dr. C. M. Richter. On account of the enormous size of the aneurism and the oedema in the tissues about it, the incision was made on the left side, parallel to Poupart's ligament, and the artery exposed extraperitonaeally. The artery was tied with a silk ligature about one-half inch from its origin. The aneurism collapsed, but the gangrene, in two days, had extended to the knee. The limb was anaesthetic as high as Poupart's ligament. Nowhere in the extremity could arterial pulsation be felt. Three days after ligation, amputation of the thigh was made. The operation was performed according to the antiseptic method of Lister. An Esmarch bandage was applied just below Poupart's ligament, and the amputation performed in a manner quite bloodless. The large arteries were filled with recently coagulated blood. On removal of the Esmarch bandage, vessels bled from all parts of the stump, and twenty or thirty blood vessels were ligated.

On the ninth day the surface of the stump appeared to be gangrenous. Chloride of zinc was applied, seemingly with good effect. On the thirteenth day afterwards, there was a rise in temperature, but the wound was granulating satisfactorily. Pus was discharged from the abdominal wound on the fifteenth day.

On the thirty-third day after operation, the patient was doing well. The ligature had not yet come away, but ultimate recovery seemed assured.

3. (Group II.) Nicoladoni. *Ligature of the right common iliac artery for spurious aneurism of the right hypogastric region. Death forty-five hours after operation.* (August Sulzenbacher. Wiener medicinische Presse, 1882, Nos. 7, 8, and 9.)

Male, aet. 31. Admitted to the Innsbruck Hospital, November 11, 1881. Four weeks before admission was wounded in the right groin with a knife. Profuse bleeding from the wound was controlled by pressure of the patient's hand until his strength failed; then, with both hands, he pressed the flexed thigh on the body in order to arrest the haemorrhage. In this position the patient was carried to the Bozener Stadtshospital. On arrival, the bleeding had ceased. A wound in the middle of the right inguinal fold, promptly closed with stitches, healed with the formation of a small abscess. Thirteen days later, apparently recovered, he left the hospital, but soon applied for admission, because a tumor had developed in the right hypogastrium, which from day to day increased in size.

Examination (on admission to Professor Nicoladoni's clinic).—Skin and mucous membrane pale, voice weak and motions strengthless. The right lower extremity, swollen, bent at knee, and hip rotated outwards. The swelling was greatest at junction of thigh and trunk, where the skin was tense and glistening, and the ramifications of the veins dilated. A pulse in the femoral artery could be felt, but it was barely perceptible in the posterior tibial. The entire right hypogastrium was conspicuously vaulted by a hard, and, in places, nodular tumor which extended from the anterior superior spine to beyond the middle line, and from two inches below the navel into the pelvis behind the symphysis. On palpation, a peculiar vibrating thrill and slight heaving synchronous with the heart's systole could be appreciated. From the rectum a hard tumefaction was felt on the right side.

Diagnosis.—"Aneurysma Spurium; masses of coagulated blood in the pelvis; wound of epigastric artery, probable; of external iliac artery, or of both these vessels, possible." It was emphasized that the femoral artery pulsated peripherally to the seat of the injury.

Operation.—Nicoladoni. November 15, 1881. Long, mid-line incision to give ready access to the large arteries in case of necessity. Then a long incision parallel to Poupart's and, finally, through this ligament in search for the epigastric artery, and to expose the femoral vessels.

On the accidental opening of the sac, a profuse spurting haemorrhage occurred. After a vain attempt to isolate the pulsating external iliac from the wall of the aneurism, the peritonaeal cavity was entered and the common iliac artery ligated with iodoformized silk. Thus the pulsation and bleeding were completely arrested. Intestines which had been eventrated to facilitate the operation were replaced and the abdominal wound sutured. Then the femoral artery was ligated peripherally, and the aneurismal sac laid open. In a small cavity, the size of a hen's egg, a hole in the upper side of the femoral (?) artery was found; a second larger cavity led into a wide subperitonaeal space. Arterial haemorrhage "from the peripheral end of the external iliac" (?) was controlled by the central ligation of this vessel. Great masses of blood coagula, black and rusty brown in color, were removed from the spurious sac, which extending into the small pelvis and filling the iliac fossa, had dissected down the thigh under the fascia lata and between the muscles. Wound closed, drained and covered with antiseptic dressing. Duration of operation, with deep narcosis, three and one-half hours.

The following day, November 16th, pain in leg and, later, in abdomen. Great thirst and restlessness. Pulse 144, temperature 102.

November 17th.—Death at 10 a. m., forty-five hours after operation.

Autopsy.—Ligature on common iliac, 2.5 cm. below aortic division. Above this point, a soft clot in the artery. Right internal iliac artery decidedly larger than the left. The crural artery together with the epigastric ligated at Poupart's ligament. In the anterior abdominal wall, the epigastric artery had been cut through not far from its origin. The femoral vein was dilated and filled with a tough and adherent thrombus, on removal of which there was found in the posterior wall of the vessel a sharp-edged slit. The femoral artery, united with dense connective tissue to the vein, was found to be again ligated below Poupart's ligament. The stabbing knife had, therefore, cut across the epigastric artery near its origin and into the femoral artery and

vein, thus confirming one of the possibilities formulated in making the diagnosis. No reference is made to the condition of the circulation in the foot.

4. (Group II.) Lange, F. *Ligation of the left common iliac artery for ileo-femoral aneurism. Cutaneous gangrene of great toe. Cure of aneurism.* (New York Medical Journal, 1883, p. 610.)

Patient, male, aet. 36. Denied syphilis, but had had leutic manifestations. In July, 1882, the patient experienced pain about the left knee, which appeared quite suddenly and caused pronounced lameness for a time. He noticed also a lump about the size of a pigeon's egg in the left groin. Never entirely free from soreness in the knee joint, he suffered at times intensely until January, 1883. The patient was seen by Dr. Lange for the first time in July, 1883. At that time, " a pulsating tumor with all the characteristics of an aneurism occupied almost the whole of the left iliac fossa, causing the abdominal wall to protrude above Poupart's ligament. Its upper boundary ran from the anterior spinous process toward the umbilicus, ending about an inch below the latter in the middle line which formed its mesial outline. A spindle-shaped process of the tumor extended in the direction of the femoral artery below Poupart's ligament. But nowhere could arterial pulsation be detected in the limb, which was cool and had a bluish hue."

Operation, July 26th.—Intraperitonaeal ligation of the common iliac artery. Silk ligature, ends cut short. " No bad symptoms followed the operation, and the vitality of the limb remained unimpaired, excepting a small cutaneous necrosis of the great toe."

Three months later the temperature of the affected limb had become more nearly normal, but it was paler in color than the other, and was less well nourished. Its sensibility was normal, but its reflex irritability was diminished. The pain had ceased and the tumor had shrunk to the size of an orange. The coolness, numbness and blueness of the leg before operation presaged insufficient collateral circulation.

5. (Group I.) Kümmel, H. *Ligation of the left common iliac, of the external iliac (twice), of the femoral (three times), and probably of the epigastric and circumflex iliac arteries, without gangrene. After, however, the ligation of three similar arteries (presumably profunda, internal circumflex and external circumflex), gangrene supervened. Recovery.* (Verhand. d. Deutsch. Gesellsch. f. Chir., 1883, and Archiv f. klin. Chirurgie, 1884, xxx, 67.)

Male, aet. 21. Following operation, by an unnamed surgeon, for bubo inguinalis on both sides, there occurred a diphtheritic inflammation of the wound of the left groin.

November 26, 1883.—(?), four days after the operation, a profuse haemorrhage took place from the eroded left femoral artery. The bleeding was arrested promptly by digital compression and artery clamps. Dr. Schede placed two ligatures of silk on the femoral artery immediately under Poupart's ligament, and divided the vessel between them. He also " tied off certain vessels opening into the artery above the ligatures." (Epigastric and circumflex iliac ?). It was found that perforation of the femoral artery had occurred in two places. The circulation of the leg was completely re-

stored by evening of the day of operation. The energetic use of concentrated solutions of corrosive sublimate arrested the diphtheritic process in the wound, but caused salivation and bloody stools. The symptoms of mercurial poisoning subsided in a few days under appropriate treatment.

November 30th.—Severe haemorrhage from the central end of the femoral artery. Although the bleeding was promptly checked with digital compression by an orderly, and then by artery clamps applied by Dr. Kümmel, the loss of blood was badly tolerated by the already greatly reduced patient.

Having transported the patient to the operating room, Dr. Kümmel ligated with catgut, extraperitonaeally, the external iliac artery, believing it wiser to operate at some distance from the infected wound, and having found it impossible to make the ligation in loco. On removing the artery forceps, which had been applied to check the haemorrhage from the femoral artery, there spurted forth a stream as powerful as before. Attempts to ligate the femoral (central end) proving again futile, the external iliac was tied once more, just below its origin from the primitive iliac, but without the least influence upon the bleeding. Hence the common iliac was ligated (with catgut, extraperitonaeally) about 3 cm. above its bifurcation. Thereupon the bleeding ceased completely. Throughout the operation the wound was almost continuously irrigated with a solution of bichloride of mercury (1-1000), and occasionally flushed with basins full of the same solution. Several thick, glass [12] drains were carried down to the site of the ligature on the common iliac; the wound was stitched and dressed with glass-wool and sublimate gauze.

The patient was in the highest degree exhausted by the operation. Pulse 120 and thread-like. The left lower extremity quite cold. On the following morning, however, the circulation of the limb was completely restored. Thus *ligation of the common iliac after double ligation of the femoral, double ligation of the external iliac, and ligation, supposedly, of the circumflex iliac and epigastric vessels had not apparently impaired the circulation of the limb, notwithstanding the greatly exsanguinated and exhausted condition of the patient.*

Needle pricks were well perceived and accurately located. Motility was unimpaired. Severe pains in the limb were ameliorated by injection of morphine.

The second day after operation (December 2d) the condition of patient and wound were relatively excellent. Pulse 96. The circulation, sensibility and motility of the limb normal. The pains had become much less.

December 10th.—Ten days after the ligation of the common iliac there came a sudden haemorrhage from the original "ligature wound" of the femoral. Although the bleeding was promptly controlled by compression of the abdominal aorta and of the bleeding point, the loss of blood was great and the patient utterly exhausted. On closer investigation, it was found that the haemorrhage came from the peripheral end of the femoral. With difficulty isolated from the disintegrated tissues, this was tied off 2 cm. below its divided end. But the bleeding remained unchecked. It came from "three thin-walled arteries about the size of a pen-quill, which ran back-

[12] Dr. Kümmel, it will be recalled, was the originator of the *Inorganischer Verband.*

wards and outwards." Were these, perhaps, the profunda, internal and external circumflex arteries?

The following day (December 11th) a livid discoloration of the foot was observed. Temperature 105° F. Pulse 144, dry tongue, delirium.

December 12th.—Pulse 156. Increase of delirium. Livid discoloration to the middle of the leg. Condition of patient so bad as to contraindicate operation.

December 13th.—The gangrene seemed demarked between the upper and middle thirds of the leg. Pulse 128. A transcondyloid amputation was made as expeditiously as possible, and then a reablation at a higher point on account of the impaired circulation in the flaps. Blood flowed from the femoral artery and vein, and also from muscular vessels. Gradually, the patient developed the picture of a chronic pyaemia. Abscesses appeared on the nates and left arm. Decubitus developed over the sacrum, and in the articulations of the lower jaw and knee. Ultimately, the patient was put in the permanent bath, in which the wound took on a healthy appearance and showed a tendency to heal. From this time the prolonged convalescence was uninterrupted.

March 3d.—Patient was able to leave his bed.

This case and Clark's (25) are the only ones in the antiseptic period which have recovered after ligation of the common iliac for the control of severe haemorrhage. In the whole literature of the subject there is perhaps no case more thrilling. In our collection of thirty cases of the antiseptic period only eight belong to Group I. Of these, four died, and one (Kümmel's) narrowly escaped death. Of the remaining three, Czerny's belongs only technically to Group I, for the ligation of the common iliac was made in the course of an operation for the removal of tuberculous glands to control slight bleeding from some artery torn off close to its parent trunk in the course of the dissection.

In Meyer's case, very briefly reported, it is not stated that the haemorrhage was severe.

The haemorrhage in Clark's case, however, was to the point of collapse.

6. (Group II.) Schönborn, Karl. *Ligation of the right common iliac for aneurism of the internal and external iliac arteries. Recovery. Cure of the aneurism.* (Setter. Zentralblatt f. Chirurgie, 1884, p. 160.)

Male, aet. 75. Difficulty in walking beginning in January, 1882, gradually increased until, in October of the same year, patient was unable to step on his right foot. About this time, there was noticed in the region of the right groin a tumefaction which rapidly increased in size, and was at first considered to be an abscess having origin in a bone of the pelvis.

In January, 1883, an aspirating needle was introduced through which "neither blood nor pus" escaped. As the swelling increased, it manifested itself in the gluteal region. At last the pain became so great that there was no relief night or day, except with the use of chloral or morphine.

Examination.—Patient seemed robust for his years, and his general condition was good. He could bear no weight on his right foot, nor walk at

all without firm support. Heart and palpable arteries were apparently normal. In the right iliac fossa a strong pulsation could be felt. On careful inspection a slight swelling was observed in the right supratrochanteric region which, fading off towards the right groin, extended behind and below the lower edge of the gluteal musculature. Above, it approached the crest of the ilium, and inwards the pubic symphysis. Throughout its entire extent, rhythmic pulsation could be seen and felt. On auscultation a systolic bruit isochronic with the pulse was heard. In the posterior tibial artery a distinct pulse could be felt. Examination by rectum revealed nothing anomalous.

Diagnosis.—Aneurism in the neighborhood of the common iliac, quite surely of a large vessel, probably of the internal and also of the external iliac. Ligation of the common iliac artery was determined upon as nothing less formidable could be done with any prospect of success.

Operation.—May 2, 1883. Prof. Schönborn. Thymol spray. An incision, 34 cm. long, concave upwards, was made from the inner third of Poupart's ligament to the lower border of the twelfth rib. The artery, exposed in the extraperitonaeal manner, had an astonishingly transverse course, and was acutely bent on itself. Its wall seemed softened. A catgut ligature was applied. It developed, on further examination, that the aneurism had its origin in the right hypogastric (internal iliac), and extended over into the external iliac artery. Both vessels gave evidence everywhere of atheromatous changes. At the moment of tying the ligature the rate of the pulse was increased from 60 to 75, and in three minutes, to 80 beats.[13] There was complete arrest of pulsation in the arteries peripheral to the ligature. The ends of the ligature were cut short, drains carried to the artery and elsewhere, the wound was sutured and covered with a Lister dressing. Notwithstanding the precautions, the wound broke down and suppurated everywhere, except at the ends and about the ligature. Necrosis of the fascia and skin necessitated numerous incisions and drainage.

The ligation exerted no manifest influence upon the limb except the blocking of the pulse. The temperature of the skin of the foot, which seemed slightly less than on the opposite side for ten days, remained normal thereafter.

Pains in the extremity were severe at first, but gradually disappeared altogether. The healing of the wound was slow, accompanied by fever and the separation of necrotic masses.

August 2d.—Three months after the operation, the wound was healed and the patient discharged. The aneurismal swelling had become considerably smaller. Pulsation neither in it nor in the posterior tibial was to be felt.

November, 1883.—Six months after the operation patient stated in a letter that he was quite well, and able to walk with a cane.

7. (Group I.) Kümmel, H. *Aneurism of the right inguinal region and the calf. Ligation of the external iliac. Secondary haemorrhage. Ligation of the right common iliac. Death in twelve hours.* (*l. c.*, p. 103.)

Female, aet. 21. Admitted to the medical division of the hospital for articular rheumatism and peliosis rheumatica. Developed aortic stenosis

[13] Compare with observation in Fluhrer's case in which the heart's action was slowed.

and insufficiency. In the further course of the disease a pulsating tumor, the size of a walnut, and causing great pain, appeared in the right groin in the region of the anterior crural nerve; a short time thereafter, a diffuse, tense, pulsating swelling in the muscle of the calf was observed. For both the diagnosis of aneurism was made.

The condition of the patient was so bad that an operative procedure was not contemplable, especially as the multiplicity of the aneurisms indicated general arterial disease.

The patient's strength continuously failing, there occurred a rupture of the aneurism in the calf followed quickly by extensive gangrene of the soft parts of the leg.

December 5, 1883.—The skin and the disintegrated tissues underlying it gave way and, thereupon, there followed a severe haemorrhage. Although this was controlled by a promptly applied Esmarch bandage, the already exhausted patient became almost pulseless as she was brought to the operating table.

As it was impossible to check, *in loco,* the bleeding, there remained only the alternatives of amputation above the knee or ligation of the main arterial stem. Amputation seemed too serious a procedure. Furthermore, it was feared that rupture of the aneurism in the groin might be brought about by ligation of the femoral artery below it. Hence the external iliac was ligated above the upper aneurism in order to cut the circulation off from this as well as from the ruptured tissues in the calf. Pulsation in the groin ceased, and the aneurismal sac collapsed completely. On removal of the Esmarch bandage, there was no return of the bleeding in the leg. Masses of clots and necrotic tissue were removed from the calf, and the great hole cleaned out and stuffed with sublimate-gauze. In two hours there was sudden profuse bleeding from the calf and, coincident with this, a tense refilling of the aneurism above, and reappearance of its pulsation.

Again, and in worse condition than ever, the patient was placed on the operating table. The common iliac was ligated extraperitonaeally, with catgut, about 3 cm. below the aortic bifurcation. The operation was performed in 15 minutes and without anaesthetic. Infusion of 800 c. c. of salt solution. Death in 12 hours.

Autopsy.—Aneurism of a branch of the profunda. The posterior tibial artery emptied into the gangrenous cavity of the musculature of the calf. A small aneurism of the right posterior cerebral artery. Insufficiency and stenosis of the aortic valves, and in lesser degree of the mitral.

This case has no bearing on either the mortality or the occurrence of gangrene after ligation of the common iliac. Haemorrhage, unpreventable in an already exhausted patient, was the immediate cause of death.

8. (Group I.) Gouley, John W. S. *Ligation of the right common iliac for diffuse aneurism of the external iliac artery. Death from pyaemia on the twenty-first day. Beginning gangrene.* (New York Med. Jour., 1885, February 28, p. 239.)

Male, aet. 22. Admitted to Bellevue Hospital, New York, October 8, 1871, for a painful pulsating tumor of the right inguinal and iliac regions.

History.—About two years before admission a heavy barrel rolling against him inflicted a contusion in the neighborhood of the right groin. Soon after

this injury he contracted urethritis and a chancre. These were followed by an enlargement of an inguinal gland which subsided without suppuration. No constitutional symptoms ensued so far as could be ascertained.

Nine months before entering the hospital he had noticed a tumor just above Poupart's ligament on the right side. Three months later he observed for the first time that it pulsated. It was then about as large as a hen's egg. The man continued to work at heavy labor, although the tumor was rapidly increasing in size and gave him great pain, of a burning character, and chiefly in the course of the anterior crural nerve.

Examination.—There was a large, pulsating, elastic tumor which extended six inches above and two inches below Poupart's ligament, and to within two and one-half inches of the median line. Over it a bellows murmur was distinctly heard. The integument overlying the swelling was dark colored and oedematous. It was thought that slight pulsation could be felt in the right anterior tibial, but not in the femoral or posterior tibial arteries.

Operation, October 12, 1871.—A curvilinear incision, nine inches long, beginning above at the tenth rib, was carried through all the structures of the abdominal wall except the peritonaeum. This was reflected upwards, and the spatula which had been used as retractor by Valentine Mott in the performance of the same operation was on this occasion held by Dr. A. B. Mott, his son, who assisted Dr. Gouley. The Mott artery-needle was also employed to carry the stout silk ligature with which the common iliac was tied. Pulsation in the tumor immediately ceased. The operation required only thirty-two minutes.

October 13th.—The tumor had softened and the pain vanished. The temperature of the limb on the operated side was found to be higher than on the other.

October 14th.—During the night the patient had a sudden attack of diarrhoea. This was checked by morphia.

October 16th.—Pulse 112; temperature 102.7° F.

October 17th.—"The tumor began to show signs of rupture"; its wall at the lower portion had become extremely thin and the overlying integument gangrenous.

October 22d.—"Dark tarry blood began to ooze from the sac through a small opening, and the sac was floating, as it were, in a pool of pus."

October 26th.—Pulse 120; temperature 102° F. Dr. Gouley "cut short the slow spontaneous enucleating process by introducing a finger and sweeping around that part of the sac which was out of sight, and at the same time removed portions of sloughy muscular tissue." After the sac had come away he could "with the finger still in the cavity, feel the bladder."

April 27th and 28th.—Chills and bed-sore. Placed on water-bed. Pulse 140; temperature 103° F.

October 29th.—Patient complained of intense pain in the heel and foot of the affected side. Sensation was absent in these parts, and their surface was cold.

October 31st.—Ecchymosis observed about the right ankle. The pain had extended up into the leg and was very intense. Chills.

November 1st.—"The ecchymosis had greatly increased."

November 2d.—Death.

Autopsy.—"The ligature lay loose in the wound. The primitive iliac artery was completely obliterated. Nearly the whole of the external iliac had sloughed away with the sac, leaving less than an inch of its lower extremity, which was entirely closed. There was a pelvic abscess which involved the psoas muscle. The femoral and iliac veins were free from thrombus."

Epicrisis.—Dr. Gouley made the following wise comment: "It seems to me that if I had carried out my intention of freely opening the sac, the chances of recovery would have been greatly increased, and that this procedure for which we had such strong warrant, and which in itself is so simple, so philosophical, and therefore so eminently surgical, should be more insisted upon than it has been of late years." The patient "succumbed from pyaemia solely because a great bag of dead decomposing blood was retained in his flank. If after ligature of the main artery the sac had been freely opened and the clots extracted, and the cavity filled with lint, I am sure that the risk of this expedient would have been infinitely small as compared with the expectant plan which was so unfortunately adopted."

The signs of gangrene (ecchymoses) which developed just before death were due, of course, in part to the enfeebled action of the heart, and probably also to the blocking of important anastomotic arteries communicating with and in the immediate neighborhood of the necrotic sac.

9. (Group II.) Jameson, L. S. *Ligation of the right common iliac for aneurism of the external iliac artery. Recovery. Cure of aneurism.* (Lancet, Lond., 1886. March 6, p. 444.)

Female, aet. 28. Admitted to Kimberly Hospital, Cape Colony, April 20, 1885.

Eleven months before admission she noticed a small swelling the size of a nut in the right groin. This gradually enlarged during the following six months, without causing pain, to the size of an apple. Then, the tumor enlarging rapidly and becoming softer, she noticed a "beating" sensation in the swelling, and pain and numbness down the leg.

Examination.—Above Poupart's ligament was an oval pulsating swelling as large as the head of a new-born child, which extended outwards to within an inch of the anterior superior spine, inwards to the mid-line and upwards to the umbilicus. The upper portion of the tumor was solid; below it was soft; the skin of a deep purple color, looked as if it might rupture on the slightest provocation. There was marked swelling of the whole of the right limb. Pulsation in the posterior tibial artery was "practically" imperceptible.

Operation, April 21st.—The tumor was so large that it was deemed impossible to expose the right common iliac by operating on the right side. The incision, consequently, was made on the left side; the left common iliac was located extraperitonaeally and traced up to the bifurcation of the aorta. The right common iliac, well overlapped by the aneurism which apparently had its origin in the external iliac, was ligated with stout carbolized silk. Pulsation in the aneurism ceased at once.

The following day, April 22d, slight pain and restlessness. Temperature a. m. 101° F.; p. m. 101.6° F. The wound showed increased discoloration at its lower part.

April 23d.—Discharge of bloody serum from wound. No pain. No abdominal distension.

April 28th.—Temperature 99° F. No pain. Superficial and deep stitches removed. Some gaping of the superficial wound.

April 29th.—Pain in the leg. Temperature normal.

May 12th.—Bed sore over sacrum, which was present on admission. Patient remained in the hospital for three months longer, the tumor diminishing slowly in size.

October 15th.—On deep pressure the tumor, quite solid, measured 2½ x 3 inches. Both the knee and the hip were considerably flexed, and patient got about with difficulty. Her health was perfect.

The operation was performed, presumably without antiseptics, for Mr. Jameson seems to have acted on the suggestion given him seven years before, as he was about to depart for Cape Colony, not to supply himself with them. Mr. John Marshall had said to him, "You are going to an antiseptic climate and don't require them." Mr. Jameson remarks that this opinion had since been fully justified. Grave injuries, such as compound fractures, which in London would have made amputation imperative, healed at Cape Colony in a marvellously short time under some simple wet dressing, such as boracic lint.

10. (Group II.) Fluhrer, W. F. *Transperitonaeal ligation of the left common iliac artery for aneurism of the external iliac.* Death on the seventh day from acute nephritis. (New York Med. Record, 1886, October 26th, p. 454.)

Male, colored, aet. 35. Admitted to Mount Sinai Hospital, May 3, 1886.

Four years before admission patient contracted syphilis. In September, 1885, he observed that the left lower limb and groin became "suddenly swollen and painful." Once the swelling in the groin was so great that he could hardly flex the thigh. Since then the swelling diminished, but at no time did it disappear.

Ten weeks before admission, the patient noticed a small, deeply seated pulsating tumor in the left groin. This steadily increased in size and in the force of its pulsations. The patient had lost twenty pounds in weight. He appeared to be only fairly vigorous.

Examination.—The tumor in the left groin was hardly noticeable on inspection, but on palpation it was found to be about two-thirds the size of a fist. From Poupart's ligament it extended upwards to a point about midway between the symphysis and the umbilicus; inwards it reached almost to the mid-line. Its pulsation was expansile, and accompanied by a faint systolic bruit. Pulsation in the left femoral artery, weaker than in the right, could be felt. The circulation of the limb on the affected side was good. There was no visible dilatation of the veins. The visceral examination revealed nothing abnormal. The urine's specific gravity was 1020, and in other respects it was normal.

Diagnosis.—Aneurism involving the whole extent of the external iliac artery.

The operation (May 20th) was conducted with thorough antiseptic precautions. The common iliac artery was tied off about one-quarter of an inch below the bifurcation of the aorta with a silk ligature, which had been boiled for two hours in a 5 per cent solution of carbolic acid. About one minute after the ligation a slowing[14] of twelve or fifteen beats was observed by Dr. Purroy, who was taking the radial pulse. Patient reacted well from the operation which had required two hours.

May 21st.—He complained of pains in the toes of the left foot. The circulation was "returning in the three lower toes." The urine contained albumen, hyaline casts, and some blood corpuscles.

May 23d.—The circulation was "good in the foot and toes." A pulse could be felt in the dorsalis pedis artery. Patient was restless. Urine was heavily charged with albumen, and contained hyaline casts in great numbers, and some blood corpuscles.

May 24th.—Pulse 140; temperature 102.6° F.

May 26th.—Patient's condition was grave. He was sluggish and unable to swallow.

May 27th.—Delirium. Died at 1 p. m.

Autopsy.—The abdominal wound had healed by first intention. The aneurism extended the whole length of the external iliac artery. The sac showed a tendency to form pouches. It was filled with a solid clot. The femoral vein was plugged with a firm, hard thrombus. The external iliac vein was impervious and lost upon the surface of the aneurism. "This condition of the veins accounts for the comparatively sudden oedema of the lower extremity and groin in the early history of the disease." The ligature had been applied three-fourths of an inch from the aneurism and one-fourth of an inch below the bifurcation of the aorta, and precisely at the point of crossing of the ureter. The common iliac vein lay exactly behind the artery. There was an aneurism of the aorta which began at the bifurcation and extended upwards for four inches. Calcified plates could be felt in the walls of the aneurism. In the sac was a clot which contrasted strongly with that which filled the aneurism of the external iliac. The former was pale, firm, laminated, and appeared adherent in places to the wall of the sac; it did not wholly obstruct the lumen of the aorta. "The remaining operative conditions," wrote Dr. Fluhrer, "that favored the development of nephritis were the prolonged and complete anaesthetization and *the change in the renal circulation.*" (Italics mine.) "If the shutting off of the main arterial blood supply to one-fourth of the body caused such a disturbance of the general circulation as to be noticed by a slowing and increase in the volume of the radial pulse, surely there must have been a more intense effect upon the renal circulation, not only from the nearness of the renal arteries to the place of ligation, but also from the presence of the clot-containing aneurism of the aorta reaching to within two inches of their origin, which

[14] Compare with Schönborn's case in which the pulse was accelerated fifteen to twenty beats on tying the common iliac.

must have been an obstacle to the free delivery of blood to the lower channels." [15]

11. (Group II.) Smith, Thos. *Ligature of the right common iliac artery with kangaroo tendon for a large fusiform ileofemoral aneurism; yielding of the knot; re-ligature with silk; gangrene of the limb.* (Trans. of the Clin. Soc. of London, 1887, xx, 29.)

Male, aet. 52. Admitted to St. Bartholomew's Hospital, October 14, 1885. An aneurism of the right external iliac artery extended from a point midway between the umbilicus and crural arch into the upper part of the thigh. The right thigh was much swollen, measuring 3 inches more than the left.

October 22d.—Ligation of the common iliac artery just above the aneurism with kangaroo tendon. The vessel at the point of ligature was very large, and erroneously supposed to be the external iliac. The ligature was cut short and the wound drained.

October 23d.—Pulsation, as forcible as before the operation of the previous day, returned in the aneurism. Fearing that the knot had slipped, the wound was opened and the common iliac religated with two ligatures of carbolized silk. The knot of the original ligature was not obviously loose, but the point of an aneurism needle could be inserted between the kangaroo tendon and the vessel. The silk ligatures were cut short and the wound drained.

October 24th.—"No pulsation in the sac. Leg warm, but darkish in color."

October 25th.—"Pulsation evident in sac; leg mottled and purple . . . . colder and insensible; thigh discolored."

October 26th.—"Pulsation in the sac increasing; condition of the whole limb much improved, as regards color and temperature." Was this perhaps due to the fact that the circulation in the aneurism was being restored?

October 27th.—"Pulsation in the sac continues, a slough forming in the calf."

October 28th.—"Pulsation continued in sac, leg and foot becoming blue. Pulse 120; temperature 103° F."

October 30th.—"Gangrene seems limited to foot and front part of leg; sac still pulsates."

October 31st.—"Pulsation in sac less, and signs of a line of demarcation; patient's general condition a little better."

"During the next two days the line of demarcation became evident, and on November 2d amputation was performed just above the condyles."

The patient died November 3d.

[15] I quite concur with this conclusion of Dr. Fluhrer as to the possible effect upon the function of the kidneys of obstruction of the arterial circulation below the renal arteries, and would refer the reader to a recent article by my former assistant, Dr. Gatch (Annals of Surgery, July, 1911, liv, p. 30), in which this question is considered. We observed in two cases that partial occlusion of the aorta in the human subject exerted a sudden and profound effect upon the renal findings. Dr. Gatch's careful study of these cases stimulated him to make experiments upon dogs and to determine the effect upon the kidneys of aortic obstruction in the healthy animal.

Autopsy.—"No general peritonitis, but some matting of the coils of intestines in the immediate neighborhood of the wound." Thrombosis of the external iliac, common femoral and profunda veins, and of the internal iliac, common femoral, superficial femoral and profunda arteries. The sac of the aneurism was quite filled with a firm laminated clot.

12. (Group II.) Lucas, Clement. *Transperitonaeal ligation of the common iliac artery for aneurism of the external iliac." "Successful."* (Brit. Med. Jour., 1892, November 26th, p. 1163. W. Mitchell Banks.)

Mr. Banks makes the following brief reference to a case of Mr. Clement Lucas: "Mr. Sheild's letter is obviously eliciting the necessary experience, as evidenced by Mr. Clement Lucas' communication, in which he reminds us of his successful case of ligature of the common iliac *through the peritonaeum* for aneurism of the external iliac artery done three and a half years ago."

13. (Group I.) Meyer, Willy. *Ligation of the common iliac artery for secondary haemorrhage incident to ligation of the internal iliac arteries for enlargement of the prostate gland. Recovery.* (Annals of Surgery, 1894, xx, p. 44.)

Male, aet. 55, admitted to the German Hospital, New York, October, 1893, for enlargement of the prostate gland.

October 5th.—Ligation of both internal iliac arteries (Bier), extraperitonaeally, by Dr. Meyer. In the act of dividing the sheath of the left internal iliac, the point of the scalpel pricked the artery. The haemorrhage was checked by the finger of an assistant on the common iliac, while Dr. Meyer ligated the artery above and below the wound in the vessel. He then divided the internal iliac between the ligatures. The haemorrhage ceased, but "suddenly it again set in in a most alarming way." The common iliac being once more compressed by an assistant's finger, it was seen that the ligature (catgut) had slipped from the proximal stump of the internal iliac. "Further attempts at properly placing a ligature proving futile, and bleeding continuing," a long artery clamp was placed on each end of the divided vessel. These were allowed to remain in the wound, being carefully packed about with gauze.

The operation on the right side was greatly facilitated by the Trendelenburg position. The right internal iliac was tied in two places with ligatures of catgut, and the artery was not divided. This wound was closed, layer by layer, without drainage.

On the fifth day, the clamps on the stumps of the left internal iliac were removed. The sutured wounds had healed throughout, the track of the forceps, of course, excepted.

"On the evening of the twelfth day, the patient suddenly noticed a hot feeling on the left side; secondary arterial haemorrhage had set in." Compression was promptly made by a well-trained nurse, then by the house surgeon who introduced his finger into the depths of the bleeding canal, and awaited the arrival of Dr. Meyer, who had been summoned. The patient was placed in the Trendelenburg posture, and the wound opened. Dr. Meyer found to his surprise that the bleeding came, not from the internal iliac, but from a hole in the external iliac artery. There was a defect, evidently caused

by the pressure of a forceps, in the anterior wall of this vessel just below the bifurcation of the primitive trunk. So the external iliac was ligated below the hole, and the common iliac above it. The catgut ligatures cut through the latter twice, and hence a ligature of silk was applied close to the bifurcation of the aorta.

"Soon after the operation, gangrene of the toes and a part of the metatarsus developed, which later necessitated irregular amputation of the anterior part of the foot." The wound of the foot being healed, the patient began to walk about and left the hospital April 28th.

So far as reduction in the size of the prostate, and the restoration of the function of the bladder were concerned, the result in the opinion of Dr. Meyer was "encouraging in the extreme." No mention is made in the report of pain in the limb following the ligation of the common iliac, nor is there any note concerning the function of this member.

14. (Group II.) Stevenson, W. F. *Transperitonaeal ligation of the left common iliac for diffuse traumatic aneurism of the external iliac and femoral arteries. Recovery. Cure of aneurism.* (Lancet, London, 1896, January 25th, p. 224. Brigade-Surgeon-Lieutenant-Colonel W. F. Stevenson and Surgeon-Major H. I. Michael.)

Patient, aet. 35, was a sergeant in the artillery stationed at Dover Castle. About October 12, 1895, patient slipped and fell with his left leg under him. He felt, at the time, a sharp pain in the left groin, but remained on duty for a week. Admitted to hospital, October 19, 1895.

Examination.—The left leg was swollen and oedematous, and the superficial veins were distended. There was a large, forcibly pulsating swelling in the left groin extending from one inch above Poupart's ligament to six inches below it, and occupying almost the entire space between the anterior superior spine to the pubes. Patient was put to bed, his limb elevated and bandaged from the foot to the middle of the thigh.

October 29th.—The tumor had become larger and was very painful. It was decided, on consultation, to ligate the common iliac on the following day. But on the thirtieth it was found that the tumor had become solid, and that the pulsation had almost ceased.

November 4th.—No pulsation could be felt, although a faint bruit was still to be heard at a spot over the inner side of the swelling. The leg was much reduced in size, and its temperature was "fairly good." Apparently spontaneous cure was taking place and the collateral circulation being established.

November 14th.—Slight pulsation had reappeared.

November 15th.—The picture had entirely changed. Strong pulsation could be felt all over the tumor, which had enlarged in every direction. The local condition was much the same as on admission to the hospital.

First operation.—Aseptic precautions. Mid-line incision. Intestines were lifted out of the abdominal cavity. Ligation, with silk, of the left common iliac artery. Wound closed. Horse-hair suture of the skin. Pulsation in the tumor ceased on tying the ligature. It was the operator's intention to continue the operation in order to turn out the clots from the sac; but as the light was bad and the tumor flaccid, further operative procedure was

deferred. The patient made an uninterrupted recovery from the laparotomy, his temperature at no time being above 99° F. The circulation in the limb was unimpaired. The tumor slowly diminished in size; the skin over it became loose and wrinkled. There was no return of the pulsation.

Second operation, December 21st.—Two and a quarter pounds of soft blood clot were removed from a huge cavity in the upper, inner aspect of the thigh, extending from the bifurcation of the common iliac artery to the central end of Hunter's canal. There was so little haemorrhage during this operation that only one ligature was required. The cavity was packed with iodoformized gauze, and allowed to heal by granulation. The circulation of the leg was unimpaired.

15. (Group II.) McBurney, Chas. *Ligation of the left common iliac artery for aneurism of the external iliac. Recovery. Cure of aneurism.* (Annals of Surgery, 1898, xxviii, 128.)

March 9, 1898, at a meeting of the New York Surgical Society, Dr. McBurney presented a young man, who, the year before, after lifting a heavy weight, felt a pain in the neighborhood of the left groin. A few weeks later he noticed a lump in that region, which gradually increased until it attained the size of a closed fist.

Examination.—The circulation in the limb of the affected side was good. The tumor presented all the characteristics of an aneurism. It terminated below at Poupart's ligament. It was decided that the ligation of the common iliac was indicated. This operation was performed December 18, 1897, transperitonaeally, and through a long median abdominal incision. In order to reach the vessel it was necessary to lift out the intestines. On tying the double catgut ligature, pulsation in the aneurism ceased, and the sac rapidly diminished in size. The wound healed by first intention. There were not at any time signs of disturbance of the circulation of the limb. The patient was discharged one month after the operation. He was able to work, but still complained of some weakness in the left leg three months after the operation. There had been no return of the pulsation.

Dr. McBurney's report of the case is very brief. No mention is made of pains in the leg, in the days immediately following the operation.

16. (Group II.) Bryant, Jos. D. *Ligation of the right common iliac artery for aneurism of the external iliac. Died in three days.* (Annals of Surgery, 1898, xxviii, 128.)

In the discussion of McBurney's case, Dr. Bryant stated that about five years before, at St. Vincent's Hospital, he ligated the right common iliac for the cure of a large aneurism of the external iliac artery, which had been present for a long time and caused the patient great distress.

He experienced some difficulty in locating the artery, as it was displaced considerably to the right side. On account of the anomalous position of this artery the left common iliac, correspondingly misplaced, narrowly escaped the ligation. The patient was in bad condition, and survived the operation only three days.

"At the autopsy it was found that the aorta rested and bifurcated on the right instead of the left side of the lumbar vertebrae." This anomaly, Dr. Bryant said, occurs in about 5 per cent of the cases.

17. (Group II.) Von Büngner. *Ligation of the left common iliac artery for aneurism of the ischiadic artery. Excision of sac, gangrene.* Death. (R. v. Varendorff. Ueber die Verletzungen und Aneurysmen der Arteria glutea und ischiadica. Inaug. Dissertation, Marburg, 1899.)

Female, aet. 66, admitted to the Landkrankenhaus, June 11, 1898.

Anamnesis.—Suffered from rheumatism ten years ago, and since then from varicose veins and ulcers of the leg; otherwise, has always been well.

In November, 1897, she noticed, on placing her hand upon the left hip, a very distinct pulsation and heaving under it. Since that time a swelling forming in the gluteal region has been slowly but appreciably increasing in size, and assuming more and more the hemispherical form. Presently pains were felt starting in the tumor and radiating down the back of the thigh to the toes. Finally the pains became so severe as to be uncontrollable by morphia.

For the past few weeks she could lie only on the unaffected side, and with thigh and knee slightly flexed.

Status Praesens.—Large, robust woman. Area of cardiac dullness slightly increased to the left and right. A blowing, mitral, systolic murmur. The second pulmonary sound accentuated. Atheromatous arteries. Pulse 88-96, small and soft. Urine normal. Highly developed varices. Scars of healed leg-ulcers. On the left buttock is a tumefaction as large as the hand of a child which, synchronous with the pulse wave, rhythmically rises and falls. The tumor is 23 cm. high by 19 cm. broad. With the hand one feels very distinct pulsations, and constates that these do not become stronger when the tumor is pressed into the buttock. The tension in the tumor is so great that fluctuation can hardly be made out. A swishing bruit is to be heard everywhere over the tumefaction. Pelvic examination negative.

Diagnosis.—Spontaneous aneurism of the gluteal or sciatic artery; mitral insufficiency; general arteriosclerosis.

Operation, June 14, 1898.—(Prof. v. Büngner.) Patient on her right side. Aneurism when exposed was blue, very tense and strongly pulsating. In the endeavor to tie all the arteries leading to the aneurism (Philagrius) a little tear in the sac wall was made, and through this there spurted a powerful stream of blood. The haemorrhage was checked by the pressure of a finger. Attempts to close the hole with suture and forceps were made in vain, and always attended with great haemorrhage. So the finger pressure had to be relied upon while the operation for the ligation of the common iliac artery was being conducted, the right-sided position of the patient being continuously maintained.

This position was found to be so advantageous for the exposure of this artery that v. Varendorf urgently recommends it as greatly facilitating the performance of this operation. The external and common iliac arteries were plainly visible. The internal iliac which could be felt and, in its central portion, seen was found to be the seat of a fusiform aneurism throughout its entire length. Fearing to apply a ligature to an artery so diseased, the common iliac was tied as the only alternative. Immediately the pulsation and thrill ceased in the gluteal aneurism.

The abdominal wound was sutured and then, without much difficulty, the collapsed sac was removed and all the vessels from it ligated. It was,

now, determined that the aneurism had its provenience in the sciatic artery. Rather troublesome was the tying off of the afferent sciatic artery, because the sac extended through the incisura ischiadica major into the pelvis. To facilitate the extirpation of the sac its posterior wall was split.[16]

The sciatic nerve was found to be so closely interwoven with the wall of the sac that it was thought to be necessary to remove about three-quarters of the circumference of this nerve.

On the following day, June 15th, the patient's condition seemed to be satisfactory. The leg on the operated side felt warm, and its sensibility was preserved. No mention is made of pain in the limb.

June 16th, p. m.—Temperature 38.2°, pulse 142, and weak.

June 17th, p. m.—Temperature 38°, pulse 124. The left foot and leg felt cold, and sensation in them was lost. There were many deep, blue spots, irregular in outline and varying in size.

June 18th.—Patient became soporific. The blue spots were increased in size and number. Without the occurrence of other manifestations, the patient died at 11 p. m.

18. (Group II.) Körte, W. *Ligation of the right common iliac artery for ruptured aneurism of the external iliac. Consecutive ligation of the aorta. Death.* (Prof. W. Körte. Deutsche med. Wochenschrift, 1900, xxvi, 717.)

Male, aet. 28.

Anamnesis.—After an excessively wearisome journey in the mountains patient was seized with severe pains in the joints. Simultaneously there appeared nodules on the extremities which disappeared after taking iodide of potassium.

Early in March, 1899, patient observed a painless, pulsating swelling above the flexture of the groin. After a long bicycle ride on April 1st, he experienced pain so severe that he was compelled to lie down. The right leg could not be used; the pains radiated down the front of the thigh, and acquired such intensity that he applied for admission to the Stadtisches Krankenhaus am Urban, Berlin, April 15, 1899.

Status.—A tall, lean, powerful, anaemic man. Temperature 38, pulse 100-110, and easily compressible. The right limb somewhat oedematous and slightly flexed at the hip; cannot be voluntarily moved. Passive movements normal.

Above Poupart's ligament, on the right side, is a pulsating tumor the size of a large apple. The walls are tensely expanded. Distinct thrill and bruit over the tumor, and extending to the left to within about 4 cm. from the mid-line, and to the right to the outer edge of the right rectus muscle. Beyond these limits there is a resistant mass which entirely fills the right iliac fossa, extends upwards to the edge of the ribs and backwards to the long muscles of the spine. The pulsating tumor extends above to a point midway between navel and symphysis, and below to Poupart's ligament. Scarpa's triangle is filled out in such manner as to press forward the strongly

[16] It has, for many years, been a favorite procedure with surgeons to split, in two or in many parts, benign tumors otherwise difficult of removal. (*i. e.*, lipomata of the back of the neck.)

pulsating femoral artery. Per rectum a thickening of the soft parts on the right pelvic wall is appreciable, and the pulsating tumor can be felt.

Compression of the aorta and of the right common iliac arrests the pulsation in the tumor. The heart is enlarged to the left. Over the aorta a diastolic murmur is to be heard and felt. Radial arteries tortuous. Urine free from albumen and sugar.

Diagnosis.—Aneurism of the right external iliac, ruptured; extensive extravasation of blood; aortic insufficiency and perhaps aneurism at the beginning of the aorta. Intraperitonaeal ligation of the common iliac was determined upon. The extraperitonaeal route was distinctly contraindicated because of the extravasated blood.

Operation, April 17, 1899.—Ligation of the common iliac with catgut. Pulsation in the aneurism thereupon ceased. For a few hours the right extremity was pale, but soon became warm and natural in color. Otherwise no disturbances of the circulation resulted from the ligation. In the femoral artery a slight pulsation was discernible. The toes could be moved; sensation remained unchanged. But for three days there were signs of intestinal paresis, nausea, singultus and tympany.

In the washing of the stomach, great quantities of dark fluid containing material resembling coffee-grounds were evacuated, and the first stools were blackish, as if blood-stained. It was concluded that the subperitonaeal extravasation had either perforated the bowel at some point, or that it had compressed the mesenteric vessels (of the duodenum or ascending colon).

The sac of the aneurism remained pulseless and without bruit. The large haematoma on the right side did not, however, diminish in size and continued to cause distress.

On the second right intercostal space, alongside of the sternum, a pulsation, which could be seen and felt became manifest. Over this area systolic and diastolic murmurs were heard. On the 6th of May, and afterwards, there were signs of thrombosis of the femoral vein. The general condition of the patient did not improve; he remained pale, his pulse became more rapid, his temperature remaining normal, and he complained continually of pains in the haematoma, which radiated to the sacrum. The active movements of the right limb became more limited and, towards the middle of May the right leg was flexed at the hip. The haematoma in the right iliac fossa became very tense. Pulsation could not be perceived either in the aneurismal sac or in the extravasation, and was greatly diminished in force in the femoral artery. It was thought that the circulation in the aneurism must have ceased, and that the perianeurismal haematoma had no direct communication with the blood stream. But as the patient remained unrelieved of his pain, it seemed indicated to open and empty the sac in the manner which had recently been recommended by Mikulicz.[17]

So 37 days after the first operation, on the 23d of May, 1899, a second was undertaken. The incision led into great masses of coagulated blood, which were extruded under great pressure. The tumor collapsed. As the cavity was almost completely emptied there took place, suddenly, a profuse

[17] Zur operativen Behandlungen der Aneurysmen. Beiträge zur klin. Chirurgie, Band xxiv, 5, 418. Hoffman.

arterial haemorrhage. This could, for a time only, be arrested by compression and tamponade. To search for the bleeding point in the enormous hole partly filled with coagula seemed unwise. Therefore, transperitonaeally, through a mid-line incision, the aorta was ligated, at first over a little bunch of gauze. Thereupon the bleeding ceased. Then, through a long cut in the right flank, Prof. Körte completely evacuated the contents of the enormous cavity. At the right edge of the true pelvis, in the neighborhood of the internal iliac, he encountered a bright, but trivial haemorrhage which was controlled by pressure. The aortic ligature was now definitely tied and the wounds sutured. The patient was greatly collapsed, and died one hour after the operation.

At the autopsy it was determined that the patient suffered from widespread disease of the arterial system, which had led to the formation of aneurism of the aorta, right and external iliac, right femoral and right profunda femoris arteries.

19. (Group II.) Martin, A. A. *Ligation of the left common iliac artery for aneurism from a bullet wound of the external iliac. Recovery. Cure of aneurism.* By Arthur A. Martin, M. B., Ch. B. Edin., Civil Surgeon, South African Field Force. (Communicated by the Director-General, Army Medical Service. Brit. Med. Jour., Jan. 17, 1903.)

Private soldier, aet. 31. Admitted, November 18, 1901, to General Hospital, Howick, Natal.

Examination.—Healed bullet wound of left groin. The wound of entrance was about three fingers' breadth above Poupart's ligament and internal to the external iliac artery. The wound of exit was below the crest of the ilium of the same side. The bullet had crossed the external iliac, "wounded the artery high up," and pierced the iliac bone. A marked bulging, expansive pulsation and bruit were noted, and the diagnosis of aneurism made.

November 23d.—The aneurism, which had greatly increased in size, now extended a finger's breadth below the umbilicus and to the middle line. The patient's temperature was 101.6° F.

Operation.—The incision began one and one-half inches above the center of Poupart's ligament, and extended to one inch above and internal to the anterior superior spine. The fascia and muscles were cut through in the line of the skin incision which, being found too short, was prolonged upwards in a curve with the convexity downwards and outwards. Peritonaeum incised. The external iliac artery could not be defined. The common and internal iliac arteries seemed to enter the upper part of the aneurismal mass. The former artery, twice ligated, was divided between the ligatures of double silk. Wound undrained and sealed. The limb was enveloped in cotton wool and firmly bandaged.

November 25th.—Patient said he could not "feel" his left leg.

November 26th.—Vomited several times. No abdominal distension. The left leg was much colder than the right. "Roots of the toes very oedematous." Limb blanched. Skin below the knee quite anaesthetic. No pulsation in tibial or popliteal.

November 27th.—Large watery blebs on leg and foot. Anaesthesia below the knee unchanged. No pain in groin since operation.

November 30th.—Patient could "feel" his leg, which seemed "heavy as lead." Temperature of left leg nearly equal to that of the other side. Blisters and oedema vanished.

December 22d.—The mass in iliac region was smaller, hard and without pulsation.

January —, 1902.—Patient could easily flex, extend and rotate leg, but was unable to "lift it vertically" when lying on the back.

February 3d.—Could walk about slowly. The mass in the left iliac fossa reduced to size of a goose egg.

The author makes the important comment that "the deep epigastric and deep circumflex iliac arteries fortunately came off below the aneurism."

20. (Group II.) Maynard, F. P. *Ligation of the right common iliac artery for diffused iliac aneurism. Death.* (The Indian Med. Gazette, Calcutta, 1903, p. 253. F. P. Maynard, F. R. C. S. (Eng.), Major I. M. S., Surgeon Superintendent, Mayo Native Hospital, Calcutta.)

Male, native, aet. 32. Admitted, April 17, 1903, to the Mayo Hospital.

History.—Patient had never had any venereal disease. Four or five months before admission he noticed a pulsating tumor in the right groin. Growing gradually larger, it did not pain him severely until a month later, when it began to increase rapidly in size.

April 7th, after a stool, he felt "as if a gust of wind ran from his abdomen into the scrotum." Thereupon he noticed that the penis and scrotum had swelled, and experienced pain in these parts.

Status.—A tall, thin man with anxious expression. Pulse 99; respiration normal; temperature 100.8° F.; cough, but no physical signs of tuberculosis. Urine normal. A large, tense, rounded, pulsating tumor, occupying the right inguinal region, extended from about 2 inches below navel to 3 or 4 inches below Poupart's ligament. This swelling was continuous with the swollen scrotum, which also had expansile pulsation synchronous with the heart's systole. A loud systolic bruit, heard over the entire area of pulsation, was loudest at the upper and outer part of the tumefaction. The penis was very oedematous. The abdominal wall, as high as the left nipple, and the upper fourth of the left thigh showed a brownish discoloration from subcutaneous haemorrhage. Feeble pulsation could be felt in the right femoral and tibial arteries.

April 20th.—A portion of the scrotum had become black and anaesthetic.

Operation.—An abdominal incision, in the mid-line, was carried below into the area of subcutaneous haemorrhage, where troublesome bleeding was encountered. The intestines gave great annoyance, and had to be brought out of the belly, where they were wrapped in warm, sterile towels. The operator regretted that he had not arranged for the Trendelenburg position. Three strands of silk were passed under the common iliac artery without difficulty. These were not drawn so tightly in tying as to cut through the inner arterial coats. Pulsation in the swelling ceased on tying the ligature.

April 21st.—Patient developed bronchitis and vomited occasionally.

April 22d.—Abdomen tympanitic. The aneurism was hard, the scrotum and toes warm. Bronchitis better.

April 24th.—Had several stools (diarrhoea), accompanied by the passage of some gas. The heat (106° F. in the shade) was very oppressive.

April 26th.—The diarrhoea and vomiting persisted. The aneurism had decreased in size. The wound seemed to be healed.

On the evening of the 27th, patient had several loose stools, and died quite suddenly. A post-mortem examination was not permitted.

The circulation of the extremity had not been manifestly affected by the operation.

21. (Group I.) Czerny, V. *Ligation of the left common iliac for the arrest of haemorrhage from a small branch of this artery torn from the parent-stem in the course of operation for the removal of tuberculous glands.* (Dreist. Deutsche Zeitschrift f. Chirurgie, 1904, p. 10.)

Male, aet. 28. Admitted to the surgical clinic for pelvic tumor. Had four years previously been admitted to the hospital for traumatic haemarthrosis genu and haematoma femoris.

Examination.—The tumor in the pelvis, although quite hard, gave evidence of fluctuation. It was movable on the ilium. Per rectum there was felt, in the neighborhood of the symphysis sacroiliaca dextra, a resistant body lying upon the bone, which it was thought might be an exudate.

Diagnosis.—Lymph glands, suppurating, and probably tuberculous.

Operation, February 26, 1897.—(Professor Czerny.) Nodular masses composed of glands were, without much difficulty, removed from along the inner edge of the iliopsoas muscle, but not so easily from the external iliac artery, which for 5 cm. was imbedded in them, mesially. In separating the packet of glands from the vessels, a small branch of the common iliac artery was torn off so near its parent stem that ligation of the latter, being considered imperative, was done. Three ligatures of thick catgut were employed, but not drawn so tight as to cut through the arterial wall. Other conglomerations were found, *i. e.*, in the pelvis and praesacral area. The removal of the diseased glands was continued without other untoward incident. It was constated that the deep epigastric vessels were not injured. The wound was tamponed.

During the first two days the left extremity was somewhat cold. There was no disturbance of sensation following the operation, nor was there any pain.

On and after the 10th of March, there were irregular elevations of temperature, at first associated with frontal headaches. Pulmonic râles were detected; then followed night sweats and slight expectoration, and on the 30th of July, 1897, the patient died of acute miliary tuberculosis.

At autopsy a double ligature was found on the common iliac artery, with associated thrombus extending to the bifurcation of the aorta. The collateral circulation seemed to have been established largely by means of anastomosis between the internal iliac arteries of the two sides without the presence of any large communicating branch.

22. Kuster, Ernst. *Ligation of the left common iliac and other arteries for elephantiasis of the lower extremities. Result negative.* (Karl Dreist, Deutsche Zeitschrift fur Chirurgie, 1904, lxxi, 32.)

Female, aet. 17. Admitted, December 3, 1897, to the surgical clinic of the University of Marburg.

Anamnesis.—Parents and five brothers and sisters alive and well. Two years ago, just after illness with nettle-rash, both legs became swollen, but without causing any discomfort. The swelling has steadily increased. Menstruation began in her 16th year and has always been irregular.

Status on Admission.—Body well nourished. Skin rather pale. Findings in thorax and abdomen normal. Pulse slow and somewhat irregular. Urine normal. Both lower extremities large and shapeless. Thighs 54 cm. in circumference. The left calf 45 cm. The feet are uninvolved. The skin feels abnormally solid; its veins here and there are dilated. There are telangiectases on the chest, left arm, forearm and hand.

Treatment.—Elevation of the limbs and compression.

December 8th.—The swelling of the thighs is diminished by 6 cm.; of the legs by 5 cm.

December 20th, a. m.—Allowed to stand for the first time; p. m., the legs are again as large as ever.

January 7th, 1898.—Ligation of the right femoral artery below Poupart's ligament. The subcutaneous fat was so thick that the finding of the artery was very difficult. The limb became paler after the operation.

January 18th.—Decided decrease in the circumference of the right extremity. The skin has become softer.

January 28th.—Ligation of the left femoral artery below Poupart's ligament.

February 10th.—Reduction in size of the left limb.

February 25th.—Patient being permitted to stand, the swelling promptly increased.

March 8th.—Extraperitonaeal ligation of the right external iliac. The vessel was very small. Tamponade. Erysipelas.

April 24th.—Extremities normal in size.

April 30th.—Patient allowed to walk. No swelling observable in the evening.

May 12th.—Swelling as great as on admission.

June 23d.—Extraperitonaeal ligation of the left common iliac. Limb cooler towards evening.

June 27th.—Temperature of both extremities the same.

August 2d.—Result of the operations negative.

23. (Group I.) Trendelenburg, Friedrich. *Ligation of the left common artery for aneurisma dissecans of this vessel. Death.* (Communicated by Dreist, *l. c.*, p. 12.)

Male, aet. 60. Admitted, October 4, 1898, to Professor Trendelenburg's clinic in Leipzig.

Examination.—General condition wretched. Patient had suffered from pain in the abdomen for a year, and on the day of admission had done a full day's work, although repeatedly complaining to his fellow laborers of drawing pains. Suddenly, about 6 p. m., very severe pains set in, and he rapidly became pale and weak.

Status on Admission.—Patient very pale and in great pain. There was eructation but no vomiting. The abdomen was greatly distended. Liver dullness normal. On the left side of the abdomen was palpated a tense, elongated tumor of the size of one's arm, which, in its course, corresponded

to the situation of the descending colon. The percussion note, nowhere metallic, was dull over the tumor. Nevertheless it was thought that perhaps there was volvulus of the sigmoid flexure, and an exploratory laparotomy was promptly made.

On incision of the abdominal wall, a large amount of blood was observed extravasated in the praeperitonaeal space. The hand in the abdominal cavity ascertained that the tumor was retroperitonaeal.

An incision was made into this haematoma. On removal of coagula there was, at first, no fresh bleeding, and there was found at the bottom of the large cavity a pulsating aneurism with rounded surface, which led towards the aorta, but was situated between the lumbar vertebrae and the psoas muscle. Suddenly there spurted from the aneurism a thick stream of blood. Compression was made; but under the compressing finger the rent in the aneurism became greater, whereupon the blood welled forth in a great flood.

The aneurism was laid freely open, and a ligature applied to its root, near the aorta. Haemorrhage from the distal side was controlled by a clamp and by tying off the rent with a strip of gauze. Skin suture. Infusion of 900 c. c. salt solution. Patient awoke from the narcosis, evinced great restlessness, and died in three hours.

Autopsy.—Dissecting aneurism of the right common iliac. Fusiform aneurism of the left common iliac, the size of a hen's egg, immediately below the aortic bifurcation. A tear of the intima, in the middle of the aneurism, transverse to its long axis. Diffuse arteriosclerosis of the entire aorta. Arteriosclerosis with calcareous infiltration of the right coronary artery of the heart and of both iliacs.

24. (Group II.) Christel. *Ligation of the left common iliac artery for spurious aneurism of the femoral. Recovery. Gangrene.* (Dreist, *l. c.*, p. 6.)

Male, aet. 28. Blacksmith. On January 28, 1901, a glowing splinter of iron penetrated the left thigh, and thereupon a strong pulsating stream of blood spurted from the wound. Patient controlled the bleeding with his thumb until the arrival of a physician, who applied a compressing bandage. Eight days after the injury, patient was allowed to go about. Severe pains, with tension in Scarpa's triangle, compelled him to take to his bed again. The swelling increased and the pains became unbearable.

March 1, 1901.—Admitted to Rombacher Spital, Metz.

Status, March 5th.—Patient was greatly emaciated and anaemic. Resembled a consumptive in the last stages of the disease. Pulse, thready (126+). Rectal temperature 36.7°. Left thigh enormously swollen. A small scar, 10 cm. below anterior superior spine, along the inner edge of the sartorius. The oedema extended to the level of the navel. Skin of the thigh livid, and its veins distended in the region of the tumor. Auscultation over it negative. Pulsation in the posterior tibial artery was distinct.

Diagnosis.—Spurious aneurism, with beginning suppuration of the femoral or a branch of this artery.

Operation, March 6th.—Incision over the greatest convexity of the tumor led into a large hole, between the extensor and adductor muscles, lined with coagula. The femoral vein was thick as a finger, tensely full and non-pulsating. Blood welled up from the depths of the wound. Attempts to

remove the clots from the infiltrated and friable tissues caused such very profuse bleeding that they were abandoned. Preparations made for the ligation of the external iliac. An incision parallel to Poupart's ligament laid bare this artery, which was then ligated below the origin of the deep epigastric, because the latter vessel was given off at an abnormally high point. During the manipulations, the epigastric was torn off and ligated. The external iliac was again ligated above the origin of the epigastric.

Then the wound of the thigh, which had been tamponed with gauze, was reinvestigated. There was still bleeding from several unrecognizable sources. The patient was so collapsed that a further loss of blood could not be sustained. Hence it was determined to ligate the common iliac. This was done extraperitonaeally. The bleeding from the wound of the thigh was thereby arrested. The femoral artery was again searched for in this wound but not found. Both wounds were tamponed with iodoform-gauze.

"After a time," the left leg became cold and insensible. A livid discoloration of the foot appeared. The gangrene extended gradually. A line of demarcation formed about the junction of the middle and upper thirds of the leg. The patient became soporific. Pulse 124; temperature 103.5° F. Notwithstanding the desperate condition of the patient, Dr. Christel amputated "the same day." Gradual recovery took place, and October 6, 1901, the patient was supplied with a prothesis.

In March, 1903, Dr. Dreist again saw the patient, who had entirely regained his health.

Whether it was the femoral, or a branch of this artery, which had been injured by the iron splinter, was never determined. What vessels besides those mentioned may have been ligated or injured is not known. It is at least certain that the gangrene is not to be attributed solely to the ligation of the common iliac. Inasmuch as the external iliac was ligated above and below the torn off epigastric artery, it is probable that the circumflex iliac also had its origin between these ligatures. The profunda femoris with its circumflex branches may have been injured either by the iron splinter or in the attempts to check the haemorrhage from the wound of the thigh.

25. (Group I.) Clark, Henry E., C. M. G. Senior Surgeon, Glasgow Royal Infirmary. *Ligation of the left profunda femoral and common iliac arteries for wound of the profunda artery and vein. Recovery.* (Brit. Med. Jour., Oct. 7, 1905, p. 850.)

This case is so briefly and picturesquely reported that I retell the story in the words of the operator.

"H. B. Porter, aged 26, was admitted into Ward 25, Glasgow Royal Infirmary, on April 25, 1899, suffering from a small punctured wound at the inner side of the left thigh, at the junction of the upper and middle third.

"His story was that he and another man were having a fight, when the latter whipped out a penknife and came at him. In trying to escape from the assault, he fell, and his assailant fell on top of him, and the blade of the knife ran into the thigh, right up to the hilt. The wound bled very freely, but a doctor was soon in attendance, who put on a pad and a bandage. When he reached the hospital the bleeding had ceased, and on the following morning, when I saw him at the usual visit hour, the wound was so well plugged

with clot that I thought it unwise to disturb it. All went well till May 12th, when the wound was found to be bleeding freely, suppuration having taken place, and the clot having consequently broken down. I thoroughly opened up the wound, and exposed the main trunk of the profunda femoris artery, which had been incompletely divided; this was double ligatured and cut across. The vein was also found to be injured, and was more difficult to secure effectively than the artery.

"Three days afterwards (on May 15th), when the patient was using the bedpan, he became suddenly blanched and pulseless, and the dressings became saturated with arterial blood. I was fortunately on the spot at the time, and at once took him to the operating theater, where I ligatured the common femoral artery just at its emergence from beneath Poupart's ligament. This arrested the bleeding, and he very rapidly recovered from the loss of blood, until five days later (May 20th), when a still more serious haemorrhage took place. On this occasion, also, I happened to be in the infirmary and at once applied an elastic bandage round the pelvis and hip, but as this did not control the bleeding, it was decided to ligature the common iliac artery. This was done by Sir Philip Crampton's method, as described by him in the Medico-Chirurgical Transactions, Vol. xvi, p. 161, as far back as 1828. The incision commenced at the anterior extremity of the last rib, proceeded downwards directly to the ilium, then followed the line of the crest, but keeping a little within its inner margin, until it terminated at the anterior superior spine. The abdominal muscles were divided in the full extent of this incision till the peritonaeum was reached, when that structure with the contained intestines was lifted up off the iliac and the lumbar fasciae. The ureter was raised with the peritonaeum. An excellent view of the external and common iliac arteries was obtained, and the bleeding was slight and easily controlled. By means of a helix-curve aneurism needle the common iliac artery was freed from a small amount of fat, and a strong chromic gut ligature passed and securely tied. The large wound was for the most part stitched up in layers, but the part in the loin was packed with iodoform gauze. The patient stood the operation well, and made up rapidly for the loss of blood. Unfortunately, the wound suppurated, but this was not wonderful, considering that there had been all along an infection of the oringal wound, probably from septic material carried in by the knife. This, however, materially delayed the healing, and it was not till August 11th that he was dismissed to the Convalescent Home.

"After leaving the wards he was only seen once by me, as he found it impossible to come to the infirmary on week-days. He was seen by one of my dressers, and also by my staff-nurse fully six months after leaving us, and was then in full employment as an outside porter at the Glasgow Central Railway Station. I understood his work to consist mainly in taking commercial travellers' large sample boxes on a hand-barrow about the town—a sufficiently trying and laborious occupation. It is not too much, I think, to claim this not only as a 'recovery' but as a perfect cure."

26. (Group II.) Cranwell, D. J. *Ligation of the right common iliac for aneurism of the external iliac and femoral arteries. Gangrene. Death.* (Tratamiento de los anuerismos de la iliaca externa. Por el doctor Daniel J.

Cranwell, Profesor suplente de clinica quirurgica. Revista de la Sociedad Médica Argentina, 1906, xiv, p. 388.)

Male, aet. 48. Blenorrhagia at the age of 16 years. Alcoholic. Thirty years ago, after a walk, he suffered with cramps in the right leg which made him halt. Later, a small tumor appeared in the right groin which for 15 years grew slowly, and then more rapidly, until August, 1903, when he received a blow in the affected regions. Ever since then the growth has increased and the leg has been swelling. For the past 30 years he has had intermittent pains in the lower part of the thigh at the base of Scarpa's triangle and in the knee, which were greater at night and with exercise.

Status.—A very lean individual in bad general condition. The thigh is flexed, abducted and rotated outwards. Occupying the base of Scarpa's triangle and the right iliac fossa, there is a tumor as large as the head of a child. Poupart's ligament indents the mass, the lower part of which, as big as an orange, is somewhat drawn out in the course of the femoral vessels. The skin over it is normal, and not adherent to the underlying tumor. The swelling is soft and expands with pulsation. The thigh and leg are oedematous. Patient suffers excruciating pain in the hip and inner part of the thigh. Motions of the joint are greatly restricted because of the pain. He has numerous subcutaneous lipomata and general arteriosclerosis.

Diagnosis.—Aneurism of the external iliac and femoral arteries.

Operation, February 28, 1904 (?).—Trendelenburg position, median incision. Transperitonaeal ligation of the right common iliac just below the bifurcation of the aorta. Immediate cessation of pulsation in the aneurism.

March 1st.—The leg was livid and without sensation from the calf to the toes.

March 2d.—Gangrene of the leg. Amputation about the middle of the thigh.

The patient's general condition improved for a time, but the wound showed no tendency to heal. The arteries were rigid and pulsated forcefully.

April 4th.—Sacral decubitus. Death.

27. (Group II.) Gillette, Wm. D. *Ligation of the left common iliac artery for the cure of ischiadic aneurism. The internal and external iliacs were also ligated and the sac dissected out and tied off. Gangrene.* (Annals of Surgery, 1908, xxxviii, 22.)

Patient, male, aet. 56. Aneurism of left sciatic artery attributed to severe fall about 17 months prior to operation. The aneurism extended so high towards the pelvis that ligation of the afferent artery was not attempted. So (April 22, 1905) the left internal iliac was tied near its origin. The patient recovered uneventfully. Pulsation ceased in the aneurism, which rapidly diminished in size. For seven months a cure was believed to have been effected. Then pulsation reappeared in a small tumor at the original site of the aneurism. Patient did not consent to further operation until three months later, when the aneurism had greatly enlarged, although not to its former dimensions, April 18, 1906. Dr. Gillette exposed the pulsating tumor in the buttock, hoping to ligate the artery leading to it, or to perform the Matas operation. Neither procedure was feasible. The abdomen was then opened and, as compression of the external iliac artery seemed to

obliterate the pulsation in the aneurism, this artery was ligated. But on reexamination of the tumor, it was found that the pulsation had not been affected in the least. So the common iliac artery was tied close to the aortic bifurcation. Then, through the incision in the buttock, the sac of the aneurism was freely opened and tied off at the highest possible point.

On the third day signs of gangrene of the leg appeared, and on the sixth day amputation was made at the juncture of the upper and middle thirds of the leg. Sloughing of the flaps necessitated amputation of the thigh. Recovery.

28. (Group II.) Halsted, W. S. *Occlusion of the left common iliac with an aluminum band for aneurism of the external iliac and femoral arteries. Recovery. Aneurism cured.* (*Case hitherto unreported.*)

M. R., German, aet. 44, was admitted to The Johns Hopkins Hospital December 28, 1908, complaining of tumefaction and pain in the left groin.

Story.—Has always enjoyed good health. Believes that he had malaria at some time. Contracted specific urethritis at the age of 22, and at the same time a venereal sore which was accompanied by enlarged inguinal glands. Has had no secondary manifestations of lues. Drinks two bottles of beer daily, is otherwise temperate. About two and one-fourth years ago, patient in falling was struck in the left groin with the iron-bound edge of a barrel. He suffered no immediate inconvenience from the trauma, but three months later felt a "drawing" pain in the left groin and leg. This pain was especially severe in the calf, and prevented him from doing much walking.

Four or five months after the injury, the leg began to swell. About September, 1908, the pain ceased, in the leg, but increased in the groin, where it assumed a "burning character." More than one and a half years ago a lump in the groin was noticed. This has been "getting larger" and tender, and patient has observed that it pulsates. The burning pains in the swelling are intensified by walking.

Status Praesens.—Patient is well nourished and seems to be robust. Examination of the eyes, ears, nose, mouth, chest and rectum reveals nothing abnormal. Radial and temporal arteries slightly hard and tortuous. Pulse 90. Cicatrices in both groins. In the left groin is a large, very tense pulsating mass, over which the skin, oedematous, reddish and glistening, is tightly stretched. The swelling extends laterally to the anterior superior spine of the ilium, mesially to the mid-line, upwards to within 8 cm. of the umbilicus and downwards to a point 12 cm. below Poupart's ligament. It measures 26 cm. in the transverse, and 20 cm. in the longitudinal diameter. It has forced the external ring downwards and the canal forwards, so that the finger cannot enter the former. The mass expands in all directions with the pulsation, the heave from which is so strong that motion is communicated to the penis and scrotum with each heart-beat. A loud systolic bruit is to be heard, and a thrill to be felt, over the tumor.

The right foot is colder than the left. Pulsation in the popliteal, posterior tibial and dorsalis pedis arteries is not perceivable. The left thigh at 20 cm. above the patella measures 51.5 cm., the right 47 cm.; the left calf 35 cm., the right 30.5 cm. The veins and venules of the left limb are enlarged.

Sensation and motility are normal. White blood corpuscles 8400. Haemoglobin 81 per cent (Sahli).

There seems to be a delay of pulsation in the tumor of three hundredths of a second. The lower edge of the swelling is abrupt, and a little overhanging. The patient rests most comfortably with the thigh slightly flexed and abducted. There is an apparent lengthening of 3 cm. of the left lower extremity.

The temperature was usually 0.5 of a degree (Fahr.) higher in the left than in the right popliteal space.

Diagnosis.—Aneurism of the external iliac and femoral arteries.

Operation, January 11, 1909.—Application of a totally occluding aluminum band to the left common iliac artery. The patient was placed in the Trendelenburg position to compel gravitation of the intestines towards the thorax.[18] A vertical incision was made through the middle of the anterior sheath of the rectus muscle. This muscle was then split near its inner edge, and its external portion retracted outwards. The posterior sheath of this muscle, the fascia transversalis and the peritonaeum were divided about in the line of the incision through the anterior sheath and skin.

It was my intention to ligate the external iliac artery if possible. The upper side of the huge aneurism presented a vertical face which seemed to be almost flat, and the external iliac artery lay at a great depth behind the aneurism. A very thick panniculus considerably increased the distance of the artery from the skin. The vertical diameter of the aneurism at its upper edge was estimated at 12 cm. to 13 cm. We possessed no retractors which could reach to the bottom of the wound, but by means of broad spatulae and the hand of an assistant, the intestines, which had been carefully displaced upwards and to the right side, were kept easily out of the way.

The left ureter promptly came into view, and beneath it the common iliac artery was recognized. This was readily isolated by means of two long fine blunt dissectors, designed especially for the dissection of the deep arteries (*i. e.,* the inferior thyroid). The left common iliac being raised from its bed by two narrow tapes, an armed band roller was passed under it in the usual manner,[19] and the band (6 cm. wide) curled by the instrument. On releasing the traction-pressure made on the artery by the tapes, the expanded vessel not only completely filled the band, but was constricted by it. A very slight additional rolling of the band with the fingers sufficed to arrest the pulsation in the aneurism, but not altogether in the common iliac artery.

The thrill, however, which is observed with a certain amount of partial occlusion of an artery had vanished. A little additional rolling of the band—so little that I was not able to appreciate with the fingers that a further constriction had been accomplished—shut the pulse off completely from the artery, which assumed a flattish shape and the almost collapsed appearance characteristic of empty arteries. The peritonaeum, transversalis fascia and posterior sheath of the rectus were closed with a continuous catgut suture, and the anterior sheath of this muscle in the same manner. The

[18] In operations upon the aorta of dogs this posture was found to be of great service.

[19] Journal of Experimental Medicine, 1909, vol. xi, 373.

subcutaneous fascia was stitched with interrupted sutures of very fine silver wire. A continuous buried mattress suture of strong silver wire was employed for the skin, because considerable traction was necessary to bring its slightly inflamed edges together over the tumor. Under such conditions catgut is useless, and silk would prove a nuisance should suppuration occur. Where there is tension of the skin, the buried silver wire suture has proved, in our experience, to be the best. The wound was covered with silver foil.

Returned to the ward at 1.45 p. m., the patient's pulse was 100, his temperature 97° F. There was no return of pulsation in the aneurism. During the afternoon he was restless and complained of pain in the left leg. The left foot seemed cooler than the right, but was of good color, though the circulation was somewhat impeded. There was no impairment of motion or sensation.

3.20 p. m. The temperature in the popliteal space is 97.4° F. on the left, 97.3° F. on the right side. At 6 p. m. the temperature of the feet is relatively the same on both sides as at 3.20 p. m., but in the popliteal space, and for a short distance down the leg, it is a few tenths of a degree higher on the left than on the other side.

Until midnight the color of the foot remained apparently unchanged. Then there seemed to be a slightly bluish tinge of the skin of the left foot, which remained for not more than two hours. At no time did the patient observe any unusual sensations in the foot, but he complained of excruciating pain in the left leg between the knee and ankle, and in no other place. Something seemed to be "bearing down on the bone, hard enough to break it." Over a small area, about 3 cm. in width, on the inner side of the calf of the left leg, the touch of the finger could not be appreciated.

January 12th, 8 a. m.—The patient's condition is highly satisfactory. The pain in the leg which persisted during the night has almost vanished. The circulation in the left foot is improved. Temperature in popliteal space 96.8° F. on the left, 96.4° F. on the right side.

9 p. m.—The swelling in the limb is diminishing; the measurements showing 2.5 cm. decrease in size at 10 cm. and 20 cm. above the patella.

January 13th.—Patient passed a comfortable night, with very little pain in the leg. The foot has remained warm and its color good. There is little distension of the abdomen. At 8 a. m., temperature 99.4° F., pulse 120, respiration 20. There is no perceptible pulsation in the aneurism or in the arteries below. The tumor seems to be softer.

8 p. m.—Temperature in popliteal space, right 98.2° F., left 98° F.

January 14th.—Abdominal distension entirely relieved.

January 15th.—Aneurismal mass seems flatter and softer. There is no observable pulsation.

January 17th.—First dressing. The tense skin is reddened along the greater part of incision, about the middle of which there is a gaping of nearly 4 cm. Patient says, "I have never felt better in my life."

January 20th.—The redness of the skin has about disappeared. There has been no further separation of the edges of the wound, the exudate from which is still serous. The swelling of the leg continues to decrease. No pulsation in the aneurism or arteries of the extremity.

January 31st.—Aneurismal mass measures 13.5 cm. by 15.5 cm. Apparent lengthening of left leg is still 2 cm. (abduction).

February 8th.—Patient has been up in a chair for the past three days. There has been no swelling of the leg incident to its dependent posture. No pulsation in the tumor. The wound is healed.

February 10th.—Patient walks without difficulty or discomfort. There is no swelling of the foot.

February 12th.—Slight pain in calf, relieved by massage. Left foot and leg slightly cyanosed.

February 15, 1909.—Sensation of entire leg normal, but at the inner side of the thigh, just below the groin, there is an area about 9 cm. long over which the patient is unable to distinguish heat and cold accurately, or to appreciate the difference between the lightly applied point and the head of a pin. The tumor mass is smaller, harder, more sharply circumscribed, and without pulsation. Patient discharged.

January 19, 1910.—(One year after the operation.) Patient writes: "I am getting along splendidly, and the aneurism has completely left me. I sometimes experience a little pain in my left leg when walking fast, otherwise can complain of nothing. Am very fat, my weight being 180 pounds."

A photograph of the groin, received a few weeks later, shows no trace of the aneurism, only a broad vertical scar.

April 4, 1912.—(Three and a quarter years after the operation.) Patient writes: "In reply to your letter of the first, I will try to explain how I am feeling. My left leg is a great deal weaker than my right. I don't limp any. I can't walk very much, as I have pains in my left leg when I do any walking, and in case it gets very cold. My present weight is 180 pounds. I have a splendid appetite, and haven't been ill since my return. All traces of the aneurism have disappeared, and it never worries me the least bit."

29. (Group II.) Beckman, E. H. *Partial occlusion by the Neff Clamp*[20] *of the left common iliac artery, presumably for arterio-venous fistula of the femoral artery and vein.* (Communicated to me by Dr. E. H. Beckman, Mayo Clinic, Rochester, Minn., March 6, 1912.)

Dr. Beckman's letter is as follows:

"Patient was a male, 27 years of age, who had been operated upon 11 years previously for osteomyelitis at the lower end of the left femur. The surgeon told him that the artery had been injured at the time of operation. He noticed a marked thrill in the femoral artery. The osteomyelitis wound healed and has given him no further trouble. Patient has had a marked thrill and increased pulsation along the entire femoral artery, and extending above Poupart's ligament, from the time of his operation, but he has been able to continue at work as a paper-hanger. He consulted us because, for the past three months, he had had increased pain and tenderness along the course of the femoral artery. We found, upon operative examination, that the femoral artery was dilated to about the size of an aorta throughout its entire length, the dilatation extending above Poupart's ligament. At our *second operation,* performed 11 days after the first, we made an abdominal incision and found that the left common iliac artery looked like the

[20] Journ. Amer. Med. Ass., 1911, lvii, 700.

extension of the aorta, being dilated to the same size as the abdominal aorta. The right common iliac artery looked like a small branch coming from the main vessel.

"A Neff clamp was applied to the common iliac artery just below the bifurcation of the aorta, tight enough to partially occlude the former vessel, but not so tight as to arrest the pulsation in the right femoral artery.

"It was thought the patient also had a small tuberculous abscess at the site of the old osteomyelitis. This presented in the scar of his original operative wound about a week following our first operation and was drained. The patient had several chills, and ran a high temperature for 24 hours following these chills, but otherwise made a good recovery.

"It has now been two months since the clamp was applied, and the patient feels that he is very much improved. He has returned home and will report to us from time to time."

30. (Group II.) Judd, Edward S. *Partial occlusion by the Neff clamp of the right common iliac artery for aneurism of the external iliac. Death.* (Communicated to me by Dr. Edw. S. Judd and Dr. B. F. McGrath, Mayo Clinic, Rochester, Minn., March 25, 1912.) Dr. Judd's letter is as follows:

"Case 61582. Male aet. 28. Examined at the Mayo Clinic, November 27, 1911.

"*Previous History.*—Ten years ago, pneumonia. Six years ago, operation for right inguinal hernia.

"*Subjective Symptoms.*—For the past year the patient has felt a throbbing sensation in the right side of the abdomen, about two inches above the hernial wound. Three weeks ago, and occasionally since then, he has suffered from sharp pleuritic-like pains in the same region on lifting. Otherwise feels well.

"*Objective Signs.*—There is a pulsating mass in the lower abdomen, slightly to the right side. A bruit is heard over the mass. Pulsation of both femoral arteries is absent. The mass pushes into the anterior wall of the rectum, low down. The inguinal glands of both sides are enlarged. The right leg is somewhat swollen. The lower abdominal veins are prominent. A scar resulting from the operation for right inguinal hernia is present. X-ray negative; Wassermann, negative.

"Admitted to St. Mary's Hospital, December 6, 1911, for observation. Temperature and pulse normal to time of operation.

"*Operation, December 29, 1911.*—A low abdominal exploratory incision was made to the left of the mid-line. An aneurismal sac occupied nearly the entire pelvis and bulged over the pelvic brim, thereby obscuring its exact origin, but affording the observation that it arose from the right side of the pelvis.

"A long oblique incision was then made in the right loin, exposing, but not opening, the peritonaeum. The latter was reflected, the aorta exposed and the right common iliac artery reached by the guidance of the pulsating wall of the aneurismal sac. The right ureter and the right common iliac vein were isolated, pushed aside, and a Neff occlusion-clamp applied to the common iliac artery about one inch above the aneurism. The clamp was then gradually closed until but a faint pulsation of the tumor was noted.

TABLE A.—LIGATION OF THE COMMON ILIAC ARTERY.—CASES REPORTED SINCE 1880

No.	Group	Operator	Published	Date of operation	Complications	Mortality	Gangrene	Indication	Comments
1	I	O'Grady.	Med. Press and Circular, 1880.	1877, Nov.	Arterio-venous fistula; infection; haemorrhage; ligation of femoral and internal iliac arteries.	+	—	Arterio-venous aneurism of the femoral vessels.	Enormously enlarged femoral and external iliac arteries, the latter "resembling a coil of intestine." Death from haemorrhage.
2	II	Richter.	Pacific Med. and Surg. Report, 1880-1.	1881, Feb.	Gangrene before operation.	—	+	Aneurism of external iliac.	Observed only one month after operation.
3	II	Nicoladoni.	Wien. med. Presse, 1882, Nos. 7, 8, and 9 (Aug. Sulzenbacher).	1881, Feb.	Haemorrhage; ligation of external iliac, epigastric and femoral arteries; thrombosis of wounded femoral vein.	+	—	Spurious aneurism of hypogastric and iliac regions.	Spurious aneurism of inguinal region. No reference is made to the circulation of the foot. Death from haemorrhage and prolonged operation (3½ hours) under profound narcosis (chloroform).
4	II	Lange.	New York Med. Jour., 1883.	1883, July.	.....	—	+	Ilio-femoral aneurism.	"Small cutaneous necrosis of the great toe."
5	I	Kümmel.	Verhandl. der deutsch. Gesellsch f. Chir., 1883.	1883, Nov.	Ligation of ext. iliac (twice), femoral (3 times), and finally of the profunda and circumflex arteries.	—	+	Arrest of haemorrhage.	The circulation of the limb remained good until, finally, the ligation of the profunda and circumflex arteries was made. Amputation.
6	II	Schönborn.	Centralblatt f. Chirurgie, 1884 (Stetter).	1883, May.	Infection.	—	+	Aneurism of internal and external iliac arteries.	Gangrene confined to highly infected wound and its neighborhood. No return of pulsation in the aneurism of the internal and external iliac arteries. "Cure." Observed only 6 months.
7	I	Kümmel.	Arch. f. klin. Chir. 1884.	1883, Dec.	Multiple aneurisms; exhausting haemorrhages; gangrene preoperative; ligation of ext. iliac artery.	+	+	Arrest of haemorrhage; multiple aneurisms.	Common iliac ligated to control haemorrhage from ruptured aneurism of calf after lig. of ext. iliac had failed to do so. Interesting to note that lig. of the ext. iliac arrested pulsation in the femoral aneur. for only 2 hrs.
8	I	Gouley.	New York Med. Jour., 1885.	1871, Oct.	Pyaemia.	+	+	Diffuse aneurism of the external iliac.	Circulation in limb not manifestly disturbed and no pain in foot or leg until 18th day. 19th day ecchymoses about ankle and intense pain in leg.
9	II	Jameson.	Lacet, Lond., 1886.	1885, Apr.	.....	—	—	Aneurism of external iliac.	Aneurism of the right ext. iliac, so large that ligation had to be made through a left-sided incision. "Cure." Observed only 6 months.

10	II	Fluhrer.	New York Med. Record, 1886.	1886, May.	Aneurism of the abdominal aorta; nephritis.	+	—	Aneurism of external iliac.	Death from nephritis.
11	II	Smith.	Trans. Clin. Soc., Lond., 1887.	1885, Oct.	Peritonitis (?); thrombosis of ext. iliac, fem. and profunda veins and of int. iliac, fem. and profunda arteries.	+	+	Ilio-femoral aneurism.	Amputation for gangrene, signs of which appeared in 24 hrs.
12	II	Lucas.	Brit. Med. Jour., 1892 (W. Mitchell Banks).	1888.	.....	—	—	Aneurism of external iliac.	Report incomplete.
13	I	Meyer.	Annals of Surgery, Phila., 1894.	1893, Oct.	Lig. of both of the internal iliac and of external iliac arteries; haemorrhage; infection.	—	+	Secondary haemorrhage.	"Partial gangrene of toes."
14	II	Stevenson.	Lancet, Lond., 1896.	1895, Nov.	.....	—	—	Diffuse aneurism of external iliac and femoral arteries.	For two weeks spontaneous cure of the ilio-femoral aneurism seemed to have taken place. "Cure." Subsequent history not given.
15	II	McBurney.	Annals of Surgery, Phila., 1898.	1897, Dec.	.....	—	—	Aneurism of external iliac.	The aneurism terminated below at Poupart's ligament. At no time were there signs of impairment of circulation. Pains in the leg not mentioned. Brief report. "Cure." Observed only 3 months.
16	II	Bryant.	Annals of Surgery, Phila., 1898.	1893 (?)	.....	+		Aneurism of external iliac.	Cause of death not given. Gangrene not mentioned in the very brief report.
17	II	v. Büngner.	Dissertation, Marburg, 1899, v. Varendorff.	1898, June.	Haemorrhage; excision of sac of the aneurism (ischiadic) aneurism of internal iliac; mitral insufficiency; general arteriosclerosis; old age (66 years).	+	+	Aneurism of the sciatic and external iliac arteries.	Operation of Philagrius (tying all vessels leading to sac) attempted prior to and completed after the ligation of the common iliac. Blue spots did not appear until the day before death. Confer case 27.
18	I & II	Körte.	Deutsche med. Wchnschr., 1900.	1899, Apr.	Multiple aneurisms (aorta, ext. iliac, femoral, profunda); haemorrhage; organic lesion of heart; thrombosis fem. vein; ligation abdom. aorta.	+	—	Ruptured aneurism of the common iliac.	The bleeding (extravasation) continued after ligation of the common iliac. The aorta was tied to arrest the haemorrhage. Patient died on 37th day after the ligation of the common iliac, and one hour after ligation of the aorta.
19	II	Martin.	Brit. Med. Jour., 1903.	1901, Nov.	.....	—	—	Aneurism of external iliac.	Narrowly escaped gangrene as there were blebs and oedema of the toes. "Cure." Observed only 2½ months.
20	II	Maynard.	Indian Med. Gazette, Calcutta, 1903.	1903, Apr.	Extensive extravasation from rupture of aneurism; diarrhoea.	+	—	Diffuse iliac aneurism.	Circulation of limb not manifestly disturbed although the aneurism must have given off the epigastric, circumflex iliac and profunda arteries.

TABLE A.—Continued

No.	Group	Operator	Published	Date of operation	Complications	Mortality	Gangrene	Indication	Comments
21	I	Czerny.	Deutsche Ztschr. f. Chir., 1904 (Dreist).	1897, Feb.	Tuberculosis.	+	—	Slight haemorrhage in course of operation.	Collateral circulation chiefly by internal iliac arteries. The common iliac was tied for wound of a small anomalous branch of this artery occasioned in course of operation. Loss of blood, insignificant.
22		Küster.	Ibidem.	1898, Jan.	Ligation of both femoral and of right ext. iliac arteries.	—	—	Elephantiasis.	Ligation of left common iliac for cure of elephantiasis. Negative result.
23	I	Trendelenburg.	Ibidem.	1898, Oct.	Exsanguinating haemorrhage from accidental rupture of sac during the operation; general arteriosclerosis.	+	—	Haemorrhage from dissecting aneurism of common iliac.	Death from haemorrhage.
24	II	Christel.	Ibidem.	1901, Mar.	Profuse haemorrhage during op.; extravasation of blood and infection; lig. ext. iliac and epigastric arts.	—	+	Spurious aneurism of femoral.	Aneurism of fem. art. and probably of the profunda. The ext. iliac ligated above epigastric and probably above circumflex iliac also. Amputation. Cure. Observed 2 years.
25	I	Clark.	Brit. Med. Jour., 1905.	1899, May.	Repeated, severe haemorrhages to point of collapse; infection.	—	—	Haemorrhage.	One of the four cases in Group I of recovery after ligation of common iliac for haemorrhage, and the only case in this group (if we place Dequise's in Group II) recovered without gangrene. "Cure." Observed 9 months.
26	II	Cranwell.	Revista de la Sociedad Médica Argentina, 1906.	1904, Feb.	General arteriosclerosis; great oedema of thigh and leg.	+	+	Aneurism of external iliac and femoral arteries.	Ilio-femoral aneurism. Profunda as well as epigastric and circumflex iliac arteries probably given off from the sac. Gangrene from toes to calf.
27	II	Gillette.	Annals of Surgery, Phila., 1908.	1906, Apr.	Lig. internal and external iliac arts.; sac opened and tied off; amputation for gangrene.	—	+	Aneurism of sciatic artery.	Confer case 17. Amputation.
28	II	Halsted.	Not hitherto reported.	1909, Jan.	.....	—	—	Ilio-femoral aneurism.	Aneurism cured. Observed 3½ years.
29	II	Beckman.	Communicated by letter, Mar. 6, 1912.	1912, Jan.	Enormously dilated femoral, ext. iliac and common iliac arteries.	—	—	Arterio-venous fistula of femoral vessels?	Employed Neff clamp, partially occluding the common iliac artery. Probably an arterio-venous fistula, caused by an operation for osteomyelitis of femur.
30	II	Judd.	Communicated by letter, Mar. 25, 1912.	1911, Dec.	.....	+	—	Aneurism of ext. iliac artery.	Employed Neff clamp, partially occluding the common iliac artery. Aneurism believed to have resulted from an operation for hernia performed six years previously.

"*Post-operative Course.*—The pulse was 130 for several hours after the operation, and then varied between this and 162 until the end. Vomiting for the first 24 hours. Severe pain in the right leg. Pulsation of femorals absent. Color of right leg good for two days. Died, January 1, 1912.

"*Autopsy.*—(B. F. McGrath.) An incision to the left of the mid-line, 15 cm. long, is firmly closed with suture. This region is bulging, and there is some ecchymosis about the suture line. In the depth of the same incision is a considerable number of clots, apparently the result of venous oozing. On the right side is a closed oblique incision about 19 cm. long, passing in front of the anterior superior spine of the ilium; this incision extends to, but not through, the peritonaeum. The right, lower extremity is very much swollen. On the inner side of the thigh there is venous thrombosis.

"*Thorax.*—Lungs and pleural cavities, nothing noteworthy. The heart is somewhat enlarged, otherwise it presents no changes.

"*Abdomen.*—Liver, moderate degeneration. Kidneys, considerable acute nephritis. A tumor extends from the umbilicus to the left side of the pelvis and down to the right groin. A Neff occlusion-clamp is in position on the right common iliac artery 3 or 4 cm. from the bifurcation of the aorta. About 2.5 cm. below the clamp the artery passes into the tumor, which proves to be an aneurism of the right iliac, its inferior extremity extending to about the beginning of the femoral artery. The left pelvic portion of the tumor consists of a fist-sized fatty mass, rather lightly attached to the aneurismal sac. The aneurism contains dark clotted blood, which is partially organized, and somewhat occludes the lumen.

"Within the artery and directly beneath the aneurism is a valve-like projection from the posterior wall of the vessel. The lateral and anterior edges of the projection are thin and unattached, but in contact with the vascular wall. Its upper surface is somewhat concave, and receives the lower end of the organized blood clot. Its structure is of nearly cartilaginous consistency, and the neighboring lining of the vessel is roughened and firm; sections from this area show principally dense fibrous tissue.

"At the autopsy nothing was found to account for the patient's death. The operation was an extremely difficult one, and required considerable time, and while the patient reacted fairly well, the reaction was not complete. I think there is no possible chance that the clamp could, even partially, have occluded the aorta."

In the opinion of Dr. Judd the operation for hernia, six years ago, was responsible for the aneurism.

Gangrene

In the thirty-two cases operated upon prior to 1860, reported by Stephen Smith, gangrene of the leg or foot occurred in five or 15.6 per cent. But on study of the reports of these cases, I find that, probably, in only a single instance might the gangrene be attributed to ligation of the common iliac. The cases are as follows:

1. Group I. (No. 7, Smith.) C. W. F. Uhde, Braunschweig. (Deutsche Klinik, No. 16, April, 1853.)

2. Group II. (No. 4, Smith.) M. Salomon, St. Petersburg. (Zeitschrift f. d. Gesammte Medicin, Bd. 12, Heft 3, 1839.)

3. Group II. (No. 5, Smith.) James Syme. (Edinburgh Medical and Surgical Journal, October, 1838.)

4. Group II. (No. 11, Smith.) A. J. Wedderburn, New Orleans. (New Orleans Medical and Surgical Journal, May, 1852.)

5. Group III. (No. 4, Smith.) C. Th. Meier, New York. (New York American Medical Gazette, May, 1859.)

Ad. 1. *Aneurism of the left gluteal artery; rupture of the internal iliac in attempt to ligate it; ligature of common iliac artery. Death on fourth day after operation.*

Autopsy.—"Internal iliac ruptured; indications of peritonitis, leg oedematous, calf red, showing signs of approaching gangrene."

In this case gangrene did not actually develop, notwithstanding the fact that the patient died on the fourth day. There were merely indications, and at the autopsy, of *approaching* gangrene. Had the patient lived, even these "signs" might not have manifested themselves. Note that the internal iliac artery was ruptured and not ligated and that five pounds of blood were lost. At autopsy the tissues about the sac were infiltrated with blood, and many pockets of blood were found in the muscles. Even, therefore, had gangrene developed during life, it would not have been attributable solely to the ligation of the common iliac.

Ad. 2. *Aneurism of the left external iliac artery; ligature of the common iliac. Recovery.*

The aneurism was traumatic, caused by the kick of a horse. It extended from four fingers' breadth above to the same distance below Poupart's ligament; in the region, therefore, in which important anastomotic vessels are located. The pulsation ceased and the tumor rapidly diminished in size after the ligation of the common iliac, and the limb which became cool at first regained its natural warmth. In this patient, nothing more than gangrenous eschars appeared on the foot which subsequently healed. It is to be noted that the situation of the aneurism in this case was approximately the same as in Wedderburn's (4), but in the former it may have been of the sacculated variety.[21]

The case is reported in great detail by Salomon in the quaint little Zeitschrift für die Gesammte Medicin, sometimes referred to as Oppenheim's Zeitschrift.

[21] From Salomon's account of the post-mortem examination, "Die Pulsader-geschwulst hatte ihren Ursprung gleich oberhalb des Ligamentum Poupartii genommen und sich auf-und abwarts verbreitet."

TABLE B.—GANGRENE

No.	Group.	Operator	Additional factors in the production of gangrene	Time of its appearance	Indication for operation	Comments
1	II	Richter.	Huge aneurism; limb enormously swollen; patient very anaemic.	Before operation. Extended to knee in 2 days.	Aneurism of external iliac.	Aneurism so large as to compel incision on opposite side of abdomen. Extraperitonaeal operation.
2	II	Lange.	Aneurism ext. iliac and femoral arteries; leg cool, blueish and pulseless before operation.	.....	Ilio-femoral aneurism.	Cutaneous gangrene of great toe only. Due perhaps to the situation of the aneurism.
3	I	Kümmel.	Haemorrhage; ligation of ext. iliac (twice), of fem. (3 times), of epigastric, circumflex iliac, profunda, int. circumflex, ext. circumflex and comm. iliac arts.	11th day.	Haemorrhage.	There were no signs of gangrene prior to the ligation of the profunda and circumflex vessels, which were tied ten days after the ligation of the common iliac.
4	II	Schönborn.	Highly infected wound.	.....	Aneurism of external and internal iliac arteries.	Gangrene confined to the wound and its neighborhood.
5	I	Kümmel.	Multiple aneurisms; gangrene from rupture of aneurism in calf; haemorrhage.	Before operation.	Haemorrhage.	Desperate case.
6	II	Gouley.	Local and general infection.	19th day.	Ilio-femoral aneurism.	Published in 1885, but operated upon in 1871.
7	II	Smith.	Infection; thrombosis of ext. iliac, fem. and profunda veins, and of int. iliac, fem. and profunda arteries.	2nd day.	Fusiform ilio-femoral aneurism.	
8	I	Meyer.	Ligation of both int. iliac arteries; infection; haemorrhage.	.....	Haemorrhage.	Partial gangrene of toes.
9	II	v. Büngner.	Arteriosclerosis; mitral systolic murmur; haemorrhage; excision of sac; exhaustion.	5th day.	Aneurism of sciatic artery.	Signs of gangrene (blue spots) appeared one day before death.
10	II	Christel.	Profuse haemorrhage during operation; ligation of ext. iliac and epigastric arteries; extravasation of blood; infection; enormously swollen thigh.	"After a time."	Aneurism of femoral and probably of profunda artery.	The ext. iliac was ligated above and below the epigastric and circumflex iliac arteries.
11	II	Cranwell.	General arteriosclerosis; thigh and leg oedematous; patient in bad general condition. Compression by the aneurism of the internal iliac art.	3rd day.	Aneurism of external iliac and femoral arteries.	The internal iliac artery seems to have been greatly compressed by the aneurism of the external iliac. This may account, in part, for the gangrene. The aneurism involved the fem. as well as the int. iliac arts. and was of the fusiform variety.
12	II	Gillette.	Ligation of internal and external iliac arts.; excision of sac (ischiadic region).	3rd day.	Aneurism of sciatic artery.	The two cases of ligation of the common iliac artery in which an aneurism in the gluteal region was excised both had gangrene (cf. case of v. Büngner).

The patient died ten months after the operation from "psoitis rheumatica"—a suppurative inflammation in the course of the psoas muscle on the affected side.

Very instructive are the findings at autopsy relative to the collateral circulation after ligation of the common iliac. Salomon injected the descending aorta with a wax mass.

"The injected wax mass had passed into both lower extremities. The arteria iliac communis sinistra had been ligated about one-half inch below the bifurcation of the aorta abdominalis, as was proved by the obliterated and narrowed portion of the common iliac; moreover, throughout its entire course, this artery was converted into a ligamentous substance; into the arteria iliaca externa sinistra some of the wax mass had been forced by way of the arteria hypogastrica sinistra (left internal iliac). The collateral circulation above the ligature had been carried on by means of the greatly dilated lowest arteria lumbalis (ilio-lumbar) whose branches communicated with those of the arteria circumflexa iliaca sinistra. The left lower extremity received its arterial blood principally through the branches of the arteria hypogastrica sinistra, which communicated freely with those of the right side, so that the injected mass by way of these had penetrated into the vessels of the left thigh; the arteria femoralis was filled with wax to about two inches below Poupart's ligament. The arteria iliaca communis, iliaca externa and hypogastrica of the right side were greatly dilated. In the left thigh the branches of the obturator and ischiadic arteries were particularly enlarged."

These observations of Salomon's are instructive in that they demonstrate the importance of the obturator and sciatic arteries, of the anastomoses between the internal iliac arteries of the two sides, and between the circumflex iliac and ilio-lumbar arteries of the same side. No mention is made of the condition of the deep epigastric artery.

Ad. 3. *Aneurism of the right external iliac artery. Mortification of the limb and, subsequently, ligation of the common iliac artery.*

Here the gangrene preceded the operation and almost necessarily increased in extent after it.

Ad. 4. *Aneurism of the left femoral and external iliac artery. Ligation of the common iliac.*

Severe haemorrhage during the operation and death on the fourth day. Gangrene below the knee on the second day; extended to the hip on the fourth day. Pulsation ceased in the aneurism.

This was an aneurism which, perhaps, gave off all the important, anastomotic branches—the epigastric, circumflex iliac, profunda, internal and external circumflex arteries—above and below Poupart's ligament.

The great loss of blood during the operation may have enfeebled the patient to an extreme degree and predisposed to the gangrene, which was

too great in extent to be conceived of as due solely to occlusion of the common iliac.

The original account of this case which was reported under the heading "Editorial"—"City Intelligence," is meagre, and was, presumably, not written by the operator, Wedderburn. As to the findings at autopsy, nothing is said of the condition of the branches of the external iliac and femoral arteries nor is the precise extent of the aneurism given. In the account of the operation, it is mentioned that the aneurism extended to within one or two inches of the bifurcation of the primitive iliac artery.

Probably there was extensive thrombosis of veins and arteries; and, as I have said, it is likely that all the arteries important for the anastomotic circulation opened into the aneurismal sac and became obliterated after the ligation. It is an established fact that the life of the limb may be imperiled by the cure, *per se,* of an aneurism.

Ad. 5. Patient, aet. 59. *Immense osteo-aneurism of the pelvis, gluteal region and femur. Ligation of common iliac.*

Second day, discoloration of the *wound and thigh;* third day, increasing discoloration; fourth day, wound dark and neighboring parts inflamed; toes and sole of foot black; gangrene continued to the hip. Gangrene appeared first about the wound. At autopsy, peritonitis was found. In this case, it would not be justifiable to assume that the ligation of the common iliac artery was alone responsible for the gangrene.

Only in case 2, therefore, might it be reasonably supposed that the ligation of the artery was the sole cause of the gangrene; and in this patient there were merely eschars which healed without surgical interference. It is to be borne in mind that the wounds in all of these cases were infected.

To Stephen Smith's 32 cases (from 1827-1860) Kummel[22] adds 15 from the septic era.

To Group 1, 3 cases, from 1863-1865 (Nos. 13, 14 and 15). In none of these was there gangrene. In Case No. 14 amputatio femoris was done before the ligation of the common iliac and hence it is not pertinent to the subject under consideration.

To Group II, 12 cases,[23] from 1861-1875 (Nos. 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46). In only two of these (Cases 39 and 41) is mention made of gangrene.

Ad. 39. Hargrave.[24] *Arterio-venous aneurism of the external iliac vessels. Ligature of the common iliac artery.*

[22] Archiv. f. klin. Chirurgie, 1884, p. 66.

[23] Consult original article for Cases 57, 58, 59, 60, 61, 62 in Kümmel's appendix.

[24] Dublin Med. Press, 1865, vol. ii.

A large pulsating tumor of the left iliac fossa which had been treated in vain by digital and instrumental compression. On the 29th day after operation, dry gangrene of the foot began. On the 45th day all the toes were mummified. The gangrene extended, and the extremity became oedematous, as high as the hip joint. On the 67th day large pelvic abscesses were opened on both sides, and great quantities of foul-smelling pus evacuated. Arterial haemorrhage from the right abscess on the 71st day. On the 73d day recurrence of the haemorrhage and death.

Note that the aneurism was of the arterio-venous variety and probably included the epigastric and circumflex and iliac vessels, that there was very extensive suppuration in the pelvis, and that gangrene did not begin until the 29th day.

Ad. 41. Maundner.[25] *Ligation of the common iliac artery for aneurism of the right external iliac. Death on the 60th day from gangrene of the corresponding extremity.*

The common iliac vein was obliterated.

From the years between 1875 and 1884, Kümmel reports only 4 cases (all antiseptically treated) of ligation of the common iliac artery, two being his own. Gangrene occurred in three (75 per cent) of these cases.

1. Group I. No. 16, Kümmel. (Archiv. f. klinische Chirurgie, 1884, p. 67.)

2. Group II. No. 47, C. M. Richter. (Pacific Medical and Surgical Journal, 1881, p. 505.)

3. Group II. No. 48, Nicoladoni. (Sulzenbacher, Wiener med. Presse, 1882, Nos. 7-9.)

4. Group II. No. 56, Kümmel. (*Loc. cit.*)

Ad. 1. *Haemorrhage from erosion of the femoral artery, following operation for bubos, and diphtheritic infection of the wound. The femoral artery was ligated three times, the external iliac artery twice, and ultimately the profunda and circumflex arteries. Gangrene of the leg. Amputation. Recovery.*

Not only were all of the above vessels ligated, in addition to the common iliac, but the patient's vitality had been greatly lowered by repeated and excessive haemorrhages. Gangrene beginning in the foot on the day after the ligation of the profunda and the third ligation of the femoral (12 days after the ligation of the common iliac) had extended more than half way up the leg on the third day. In this case, certainly, the ligation of the common iliac artery was not alone responsible for the gangrene.

Ad. 2. *Aneurism of the external iliac. Ligature of the common iliac. Gangrene of the leg. Recovery.*

[25] Med. Times & Gazette, Oct., 1867 (Maundner).

The aneurism, as large as the head of a child, was non-pulsating. The leg of the affected side was twice the size of the other. Ligation of the common iliac was undertaken because gangrene was beginning and the aneurism was increasing in size. Note that the gangrene antedated the operation.

Ad. 4. *Aneurism of the inguinal region and of the calf of the leg. Bursting of the latter aneurism. Ligation of the external iliac. Subsequent haemorrhage. Ligation of the common iliac. Death in 12 hours.*

Gangrene of the calf of the leg in the infiltrated tissues along the ruptured aneurism, occurred before the ligation of the common iliac artery. In not one of the three cases, therefore, was uncomplicated ligation of the common iliac artery responsible for the gangrene.

For the nine years from 1884, the date of Kümmel's paper, to 1903, the year of his own communication, Dreist was able to add only 6 cases to Groups I and II, none to Group III. One of these (Trendelenburg's) died of haemorrhage three hours after the operation. In two (Christel's and v. Varendorrf's) of the remaining five gangrene occurred (40 per cent), but it was not due, primarily, to ligation of the common iliac in either case.

1. Group I. (No. 3, Christel, 1901, *loc. cit.*, p. 6.)

2. Group II. (No. 5, v. Varendorrf, 1898. Dissertation, Marburg, 1899.)

Ad. 1. *Spurious aneurism, presumably of the femoral artery, caused by splinter of iron. Ligation of the left, common iliac artery. Gangrene of leg. Recovery.*

Greatly emaciated patient; pulse 126-130; temperature 34.7°. Left thigh tremendously swollen, the tumefaction extending from knee to navel. In the course of the operation, the external iliac was twice ligated. The epigastric artery which was given off from the external iliac between the two ligatures was also ligated. Finally a ligature was placed on the common iliac artery; as further peril to the circulation of the leg there was deep suppuration of the oedematous thigh. To attribute the gangrene in this case to ligation of the common iliac would be unreasonable.

Ad. 2. *Injuries and aneurisms of the gluteal and sciatic arteries. Ligation of the left common iliac artery. Gangrene. Death.*

Woman, aet. 66. Pulsating tumor as large as a child's head in the left ischiadic region. Attempt made by the operator to ligate all the vessels contributing to the aneurism and to extirpate the sac (Philagrius). Accidental tearing of the sac. Ligation of the internal iliac artery which proved to be the seat of a fusiform aneurism. Immediately upon discovery of this, ligation of the common iliac artery which, in turn, presented several small, fusiform dilatations of its calcified wall. Extirpation of the sac and of two-thirds of the imbedded sciatic nerve. Tamponade. On the second day, gangrene of the entire leg. On the fourth day, death. The ligation of

the common iliac was, accordingly, only one of the several factors which contributed to the gangrene.

In Kümmel's collection (1884), only four cases in Groups I and II are from antiseptic times (Nos. 2, 3, 5, and 7 of my Table A). As I have said, in three of these (two of them his own) gangrene occurred, but in two of the three the gangrene had manifested itself before the ligation of the common iliac. The number of his cases is too small for statistical purposes.

For Groups I and II in the antiseptic era, Dreist, 1903 (*loc. cit.*), collected ten cases—five for each group. Five of these had gangrene. Hence he concludes that "the chief danger" from ligation of the common iliac artery "is still today the gangrene which results in its consequence."

Gillette in 1908 (*loc. cit.*) could add only one case (Martin's) beside his own to the collection made by Dreist in 1903. He makes the statement that "gangrene of the leg has occurred in the last twenty-one cases seven times, or in 33⅓ per cent."

Matas, in a masterly article of 333 pages on the Surgery of the Vascular System (Keen's Surgery, 1909, Vol. V, p. 337), writing of ligation of the common iliac artery, says that "In the 21 operations done since 1880, presumably with antiseptic precautions, gangrene occurred 7 times, or in 33.33 per cent."

Gillette and Matas must have included in their calculations ligations of the common iliac artery performed with objects in view other than the arrest of haemorrhage and the cure of aneurism, cases complicated, some of them, by desperate operations such as disarticulatio interilio-abdominalis, and which belong to the Groups III and IV of Stephen Smith.

In the thirty cases (Groups I and II) of ligation of the common iliac artery published since 1880, and collected in this paper, gangrene has occurred twelve times, or in 40 per cent (*vid.* Table B).

Table B has been arranged to enable the reader to see at a glance [26] the factors other than the ligation of the common iliac artery which have been instrumental in the production of the gangrene.

Two of the twelve cases (Nos. 1 and 5), can be excluded because the gangrene had manifested itself before the ligation of the common iliac was undertaken.

In one (No. 9) signs of gangrene ("blue spots") appeared on the fourth day when the patient, aged and exsanguinated, was almost moribund. She died the following day. In this case, the sac of a sciatic aneurism had been excised.

[26] The reader is referred also to the abstracts which I have made of these cases.

In Case 4 the gangrene, which consisted in the casting off of sloughs, was confined to the operative wound and its environs, and was due to an intense local infection. There was no gangrene of the foot or leg.

Perhaps the most striking instance in the literature of the extent to which the main arteries may be tied without manifest disturbance of the circulation of the limb is furnished by a case of Kümmel's (Table B, No. 3). In this patient, who was exsanguinated by terrific haemorrhage almost to the point of death, there were ligated the common iliac, the deep epigastric, and the circumflex iliac, the external iliac twice, and the femoral three times, and all without the production of signs of gangrene. It was not until eleven days after the ligation of the common iliac and when three vessels in the neighborhood of the profunda femoris had been tied, that gangrene supervened.

Gouley's case, No. 6, although not published until 1885, was operated upon in 1871, in the highly septic times. The patient died of infection on the 21st day, the gangrene manifesting itself not until 48 hours before death.

In No. 7, the case of Thos. Smith, there were, as complications resulting from infection, thrombosis of the external iliac, femoral and profunda veins, and of the internal iliac, femoral and profunda arteries. The aneurism involved the femoral as well as the external iliac artery and was of the fusiform variety. I should think that, in this locality, ligation of the common iliac for the obliteration of a fusiform aneurism might be more likely to be followed by gangrene than if performed for the cure of a sacculated aneurism, because from the fusiform variety, the deep epigastric, the circumflex iliac and the profunda arteries are given off, which they may not be in the case of the sacculated or spurious varieties (*vid.* also Cranwell's case, No. 11).

In Meyer's case, No. 8 (ligation of the external and both of the internal iliac arteries), infection and haemorrhage should be regarded as factors contributing to the gangrene which involved only the toes, and these only in part.

No. 10, Christel. In this instance it is clear that the complications must have been largely influential in the production of gangrene. Profuse haemorrhage occurred in the course of the operation. The external iliac artery was ligated both above and below the origin of the deep epigastric and circumflex iliac arteries, the latter of these being independently tied. There was extensive extravasation of blood, the thigh was enormously swollen and the tissues infected. The aneurism was of the femoral artery and probably involved the profunda.

No. 12. Gillette ligated the internal and external iliac arteries, as well as the parent stem and excised an aneurism of the sciatic.

In ten of the twelve cases, therefore, it would be unfair, indeed absurd, to attribute the gangrene to the ligation of the common iliac artery.

The cases of Lange and Cranwell remain to be considered. In one of these, Lange's (No. 2), there seems to have been no complication and we must assign as cause for the gangrene the ligation of the common iliac artery. The gangrene was, however, very trivial, involving, as it did, only the skin of the great toe.

The situation of the aneurism may have been a factor in the determination of the gangrene. It involved the femoral as well as the external iliac arteries.

Cranwell's case (No. 11) is the only one known to me, operated upon in antiseptic times,[27] in which *significant* gangrene has occurred after ligation of the common iliac artery not complicated by other factors contributing to the serious disturbance of the circulation in the limb. The publication is in Spanish. The case seems to be fully reported and well presented and I have no reason for believing that there is anything to be read between the lines. As stated in the text and shown in a semidiagrammatic illustration, the internal iliac artery was compressed, possibly occluded, by the aneurism which involved not only the entire external iliac but also the femoral artery. It was noted before operation that the thigh and leg were oedematous, that there was general arteriosclerosis and that the patient's condition was bad. The aneurism had existed for fifteen and perhaps for thirty years. Attacks of cramps in the limb of the affected side, severe enough to prevent locomotion, had been present for thirty years (conf. abstract).

The case is a remarkable one, but must nevertheless be accepted for the present as furnishing an instance of the production of gangrene from ligation of the common iliac artery.

Granting that in the case of Lange and Cranwell the ligation of the artery was solely responsible for the gangrene, we have only two such cases in the thirty of my collection, a percentage of six and six tenths.

If it should appear later that Cranwell's case might, for unascertained reasons, be excluded, the percentage would, of course, be three and three tenths, and the sum total of gangrene the cutaneous necrosis of one toe.

The Anastomotic Circulation

It would involve much labor to determine what the actual danger of gangrene is from ligation of the various arteries. The factors contributing to the gangrene in each reported case would have to be duly considered.

The percentages have been computed by many authors and although between the minimum and maximum estimates there may be great variation,

[27] Antiseptic precautions were presumably observed.

there seems to be little doubt as to the relative frequency with which gangrene has manifested itself after ligation of one as compared with another of the principal vessels of the extremities.

There is abundant evidence in support of the view that, in a general way, the larger the artery, or the nearer it is to the heart, the less the impairment of the circulation attending its ligation. The subclavian, for example, may be tied quite without fear of gangrene, whereas from ligation of the axillary artery the circulation of the extremity is somewhat endangered, but not so much as from ligation of the brachial.

Peripheral gangrene has not been observed in consequence of ligation of the aorta. It may occur after ligation of the common iliac, has occurred much more frequently after ligation of the popliteal artery in a considerable percentage of the cases.

Kümmel, offering the generally accepted explanation of the imperfect law, writes:

"It seems, naturally within certain limits, that the nearer the ligated vessel is to the central organ of the circulation, the easier it is for the collateral routes, *by means of the increased pressure from the heart,* to develop; this certainly seems to hold true of the vessel which we are considering (common iliac).

"Astonishing as it may seem, it nevertheless appears to be a fact, as already stated, that the ligation of the common iliac less endangers the vitality of the lower extremity, and makes easier the establishment of the collateral circulation than does the ligation of a peripheral vessel, for example, the external iliac.

"I do not hesitate, therefore, in the case of aneurisms of the external iliac and high femoral arteries, to express a preference for the ligation of the common iliac, even when ligation of the external iliac is possible, for, thereby, the definite cure of the aneurism seems to be more certain of accomplishment, and the life of the limb is less endangered."

Surely one would not, with the hope of diminishing the danger of gangrene and in order to produce a condition equivalent to the tying off of the parent trunk, ligate the internal iliac after ligation of the external iliac had been made. Ligation of the common iliac is not, of course, equivalent to ligation of the external and internal iliacs, unless one or the other of these branches is obturated at a lower point, as by aneurism; or unless they are ligated so close to the parent stem that no blood can pass from one to the other over the spur of bifurcation.

May it not be, inasmuch as in the cure (spontaneous or operative), *per se,* of certain aneurisms there lies danger to the life of the limb, that the particular situation of the aneurism may be an important factor in the determination of gangrene, and that, for example, the aneurisms for the cure of which ligation of the common iliac has generally been done are less likely

to impair the vitality of the limb than are the aneurisms for which ligation of the external iliac has usually been undertaken?

The obliteration by any method of ilio-femoral aneurisms giving off the deep epigastric, circumflex iliac and profunda arteries might well be followed by impairment more or less serious of the circulation of the foot and leg, whereas the cure of an aneurism of the external iliac artery terminating above the origin of one or more of these branches should not be attended with equal consequence.

As shown by Porta,[28] Pirogoff [29] and Kast,[30] and as observed by myself, the epigastric and circumflex arteries are of great importance in the establishment of the collateral circulation after ligation of the abdominal aorta. Salomon and Czerny have emphasized the great dilatation of the internal iliac and its branches after ligation of the common iliac artery. The anastomoses between the two internal iliacs are very free and numerous, and through these the blood reaches the femoral artery chiefly by way of the profunda. I have already called attention to the interesting fact that in Kümmel's case (Table A, No. 5) the circulation of the limb remained good until the profunda and its circumflex branches were occluded, although the common iliac, the external iliac (twice) and the femoral (three times) had previously been ligated.

We find additional demonstration of the importance of the anastomoses between the internal iliac arteries of the two sides after ligation of the common iliac in the two cases of our collection in which the sac of an aneurism in the gluteal region was excised. In both of these gangrene supervened.

Ligation in continuity should rarely be resorted to, for when branches are given off between the sac and the ligature, the circulation of the limb is more impaired than by ligation, tangential to the sac, and for the reason that the artery becomes obstructed in two places, at the site of the ligation and of the aneurism.

Partial Occlusion

It may be asked, "What is to be gained by partial occlusion of the common iliac, if its object is the cure of the aneurism and obliteration of the arteries given off from the sac?" The reply is that with the partial occlusion of the parent trunk, the direct circulation through the internal iliac

[28] Della Alterazioni Patologiche Della Arterie Per La Ligatura E La Torsione. Esperienze Ed Osservazioni Di Liugi Porta. Milano, 1845.

[29] Pirogoff. Journal der Chirurgie und Augenheilkunde. v. Walter und v. Gräfe, 1838, xxvii.

[30] Kast, Deutsche Zeitsch. f. Chirurgie, xii, 405.

is not obturated. I believe, however, that the common iliac artery, partially occluded by a metal band, will ultimately become completely obstructed. My experiments on the aorta of dogs afford ample proof for the belief that even a small direct stream is of great value. Thus a considerable mortality attended the complete occlusion of the aorta in dogs, whereas with partial obstruction by the metal band, death rarely occurred. In man, I have in four instances had the opportunity to observe the effect of partial occlusion of the aorta. In no case were disquieting symptoms manifested, although in one patient the femoral pulse was obliterated by the partial obstruction and reappeared only on agitation or exertion.

These results are in striking contrast with those consequent to ligation of the aorta.

A fusiform aneurism of the aorta was so greatly reduced in size by partial occlusion with the metal band that relief from the symptoms was obtained and the aneurism was believed to have been almost cured. But the patient died in six weeks from a sudden haemorrhage due probably to atrophy of the diseased arterial wall and the cutting through of the band.

A band was applied one and a half years ago to a greatly dilated vein proximal to an arterio-venous fistula, which had been painstakingly explored in the hope that the opening might be closed without obliteration of either the vein or the artery. The patient, an old man, with advanced arteriosclerosis, has recently sent me word by his physician, Dr. Fox of Greenville, Tenn., that his condition is greatly improved by the operation.

The partially occluding metal band has already been applied by me in man to all of the principal arteries, to the aorta four times; innominate, once; subclavian, twice; carotid, many times; femoral, three times; popliteal, once; and without accident except in the aortic case, referred to above, which will probably be reported later by the eminent director of a European clinic.

The partial occlusion, with a metal band, of an artery, other than the aorta must, ultimately, it seems to me, bring about total obliteration of its lumen. Occasionally the aorta becomes converted, under the band, into a solid fibrous cord. This has occurred, thus far only in cases in which the vessel was almost completely occluded.

But I have been constantly apprehensive lest, in the case of the aorta, the wall might ultimately give way, atrophying slowly but surely, under the pressure exerted by the constricting metal. As our laboratory for experimental surgery is closed during the summer, it has not been feasible for me to observe the ultimate effect of a partially occluding band upon the aorta for a period longer than 7½ months. In many instances, however, I have noted a thinning of the aortic wall under the band, and in some the attenua-

tion has been so great that I could foresee no outcome other than perforation of the wall of the artery.

In total occlusion of the artery the band in three animals was found embedded in a strong, fibrous capsule continuous above and below with the arterial wall. In this manner haemorrhage was prevented, notwithstanding the fact that the aorta as well as the fibrous capsule were patulous throughout. The band was, however, so snugly embraced by the surrounding cylinder of fibrous tissue that little, if any, blood could pass between the two.

But in the cases of partial occlusion of the aorta no such fibrous capsule was forming, and for the reason, undoubtedly, that there was no occasion for its formation. The occasion would, probably, come sooner or later, and perhaps, altogether without warning, or too quickly for efficient response from the surrounding tissues.

Hence, if a partially obstructing metal band is applied to the aorta, it would seem that some further operative procedure must usually be contemplated, even if the aneurism should be apparently cured. It might consist in partial occlusion of both common iliac arteries (this might be done as part of the original operation) and later of complete occlusion of the aorta, by bands or possibly ligatures, both above and below the original band. In the cases in which it may be ventured to close the aorta almost completely, the fibrous-cord formation might be hoped for, and the omission of a second operation justified.

We noted further in our experiments that the aorta of dogs after having been totally occluded by silk ligature may again become patulous. This restoration of lumen is brought about by the cutting through of the ligature, and has usually been accompanied by the formation of a diaphragm of greater or less extent.[31] Similar observations have been made upon the human subject after the ligation of large arteries (innominate, subclavian, femoral).

Acting on this hint given by nature, I tested, last winter, on thirteen dogs, the effect of partially occluding ligatures of fine silk, placed one above the other on the aorta, hoping that we might obtain a series of superimposed diaphragms which, if sufficient in number and extent, might sufficiently obturate the aorta to bring about the cure of an aneurism.

But these partially occluding ligatures of very fine silk, not only produced no diaphragms, but gave rise in two of the thirteen dogs to fatal haemorrhage.

From the totally occluding, crushing, coarse, silk ligature in dogs, I have seen no case of haemorrhage. Was, then, the fineness of the silk or the incompleteness of the occlusion responsible for the bleeding? Or were both concerned in bringing about the result?

[31] Jour. of Exp. Med., 1909, vol. xi, no. 1.

We are now testing the behavior of organizable tissues used as bands to constrict the aorta. Spiral strips and cuffs cut from the fresh aorta of one dog are wound about the aorta of others. I should fear, however, that tissues capable of organization under such circumstances would be stretched[32] by the dilating force of the aortic pulse. Should they serve their purpose for a time, enough might possibly be accomplished to enable one at a subsequent operation to produce, if necessary, complete occlusion in some other way.

[32] June 3, 1912. Since going to press one of two dogs operated upon Apirl 29 for the purpose of testing the effect of cuffs and of spiral strips of the fresh aorta of one dog wound about and constricting the aorta of others we examined today under ether, and to our delight and surprise found that the aortic cuff which had been used in this experiment seemed to be completely organized and had not, apparently, stretched in the least. The aortic pulse immediately above the constricting cuff was forcible; just below the cuff it was feeble but countable, and at this point a barely perceptible thrill was appreciable. The left femoral pulse could with difficulty be felt and counted by Dr. Goetsch who with Dr. Jacobson assisted me in making the examination, but on the right side (smaller artery) it was questionable whether or not the pulse could be appreciated with the finger. Having clamped all the aortic branches up to the band, it was noted on removal of the clamp from one of the common iliac arteries that the blood trickled feebly and with barely perceptible pulsation from the open end of the vessel. On dissecting the aorta after removal from the body, it was ascertained that the cuff which seemed, as it were, welded to it had not stretched or become thinned or altered in appearance. A fine probe passed into the aorta was snugly embraced at the site of the cuff. The artery was split open at both ends up to the cuff and the fine opening and characteristic wrinkling of the constricted vessel noted. There was almost no reaction about the cuff which seemed to be organized. Even its free flaps had retained their original dimensions.

Another dog, operated upon on the same day and in the same manner, except that a spiral strip of aorta instead of a cuff was used for the band, died suddenly about three weeks after the operation. In this instance the aorta had been almost completely occluded by the spiral band the turns of which had been held by three fine silk sutures, two applied at the pointed ends of the spiral strip and one near its middle. Dr. Jacobson, who kindly took charge of the dogs after operation, removed the specimen which I have just examined. The findings are precisely the same as in the first case. The weld-like band had not stretched, and the aorta, on being split longitudinally, was seen to be greatly wrinkled and almost occluded at the site of the seemingly organized spiral strip. There was no adhesion between the folded intimal surfaces which had been so firmly held in contact.

Thus, perhaps, at last, a safe and reliable method for occluding the aorta has been found, and an interesting and promising field for investigation opened.

Fresh tissues of other kind may serve the purpose quite as well as the aortic cuffs or strips. This remains to be determined. We await the findings of the histological examination of the specimens with much interest.

In similar manner, with band of fresh tissue, partial and complete obstruction and isolation of the intestine might be produced.

Lateral excision of a piece of the aortic wall and suture of the defect might easily be accomplished experimentally, but in the presence of aneurism this would, I fear, rarely be feasible; for the aneurism usually occupies so much space that there is not sufficient room above it, for example, between it and the renal arteries, for the carrying out of any such measure. Ordinarily it would be difficult to obtain more than room enough for the application of a band.

Function

Unfortunately there are not sufficient data to enable me to formulate conclusions as to the ultimate usefulness of the limb after ligation of the common iliac.

In Table C is embodied all that we have learned in one hundred years concerning the function of the limb following this operation.

Seven of the thirty-two cases tabulated by Stephen Smith recovered. One of these (Guthrie) belongs to Group III. Of the remaining six cases, one (Deguise) is in Group I, five (Mott, Salomon, Peace, Hey, Garviso) are in Group II.

Deguise's patient left the hospital in five weeks. There is no note of subsequent observation. For the study of function this case might be considered under Group II, for the operation which resulted in the ligation of the common iliac was undertaken for the cure of an inguinal aneurism. It was only in the course of the operation that haemorrhage necessitating the ligation of the common iliac occurred. (*Vid.* Am. Jour. Med. Sc., Oct., 1841, p. 475.) If this case were transferred to Group II, the mortality for ligation of the common iliac prior to 1860 would be 100 instead of 91 per cent.

Mott's patient, observed $3\frac{1}{2}$ months, stated at the end of this period that his leg was as strong as the other. While the memories of the agonizing pains suffered before the operation were still vivid, it is supposable that he might in his joy at being relieved of his torture and in his desire to emphasize his gratitude to his deliverer have overestimated the relative usefulness of the limb.

It will be observed that my patient, operated upon three and a half years ago, wrote enthusiastically of the result a year after being cured, but now realizes that he is considerably incapacitated. Salomon's patient died ten months after the operation from a suppurative inflammation in the course of the psoas muscle on the affected side. It is stated that the patient of Peace was able to provide for his family, pursuing the arduous occupation of loading boats with stones. But about 14 months after the operation, a small, soft, non-pulsating tumor appeared at the site of the aneurism.

TABLE C.—FUNCTION IN CASES RECOVERED WITHOUT GANGRENE

No.	Group	Operator	Date	Time observed	Function
1	II	Mott.	1827	3½ months.	Patient states "leg is as strong as the other."
2	II	Salomon.	1837	10 months.	"Psoitis Rheumatica" (psoas abscess).
3	I	Deguise.	1840	5 weeks.	
4	II	Peace.	1842	14 months.	Able to work. Died of recurrence of aneurism (haemorrhage).
5	II	Hey.	1843	6 weeks.	
6	II	Garviso.	1843		
7	II	Luzenberg.	1846	.....	No note as to function or time observed.
8	II	Bickersteth.	1862	37 days.	
9	II	Cock.	1863	"A few months."	"No untoward symptoms."
10	II	Jameson.	1885	6 months.	Flexed knee and hip.
11	II	Lucas.	1888		
12	II	Stevenson.	1895	5 weeks.	
13	II	McBurney.	1897	3 months.	Weakness in left leg.
14	II	Martin.	1897	2½ months.	Could walk about slowly.
15	II	Küster.	1897	.....	Elephantiasis (operation for).
16	I	Clark.	1899	9 months.	Resumed work as porter at railway station.
17	II	Halsted.	1909	3¼ years.	Can walk only a short distance. Pain.
18	II	Beckman.	1912	2 months.	Arterio-venous fistula (operation for).

Perforation of the skin and haemorrhage took place in a few days, and in eleven days thereafter he died.

Nothing is known of the cases of Hey and Garviso after leaving the hospital.

Kümmel adds to Smith's list two cases of cure between 1860 and 1880 (McKinlay's, Group I, and Cock's, Group II).

McKinlay's case is not pertinent for the study of function, for the thigh was amputated. In Cock's case there is a note that when seen "a few months after leaving the hospital there were no untoward symptoms," and that he resumed his occupation.

Hence for the septic period only one case (Peace, 14 months) was observed long enough to be considered in estimating the usefulness of the limb.

Of the thirty cases of the antiseptic period, fourteen died. Of the remaining sixteen, seven had gangrene. Of the nine without gangrene (and these, of course, are the only ones to be considered under the heading of function) there is in two (Lucas and Stevenson) no record of observation after the discharge from the hospital. In one (Küster) the operation was performed on a patient incapacitated by elephantiasis. Of the others, Beckman's was observed for two months ("improved"), Martin's for two and one-third months ("could walk about slowly"), McBurney's for three months ("weakness in left leg").

At the end of six months, Jameson's patient walked with difficulty. The hip and knee were flexed.

Clark's patient, observed for nine months, worked as a porter, wheeling a barrow about a railroad station.

My patient is still under observation, three and one-quarter years since the operation. April 4, 1912, he wrote me:

"My left leg is a great deal weaker than my right. I can't walk very much as I have pain in my left leg when I do any walking and in case it gets very cold. My present weight is 180 pounds. I have a splendid appetite and haven't been ill since my return. All traces of the aneurism have disappeared and it never worries me the least bit."

Mortality

Stephen Smith in reviewing the result in the cases of his first group writes:

"Of 11 cases, 10 were fatal, one recovered, being a mortality of nearly 91 per cent. The success of this operation upon the primitive iliac artery for the causes above assigned, presents a striking contrast with the operation upon the external iliac for the same class of diseases and accidents. Of 14 cases of deligation of the external iliac artery for the arrest of haemorrhage, I find that 11 were successful and three fatal, the mortality being about 21½ per cent."

TABLE D.—THE MORTALITY AND ITS CAUSES

No.	Group	Operator	Survived operation	Cause of death	Indication	Comments
1	I	O'Grady.	7 hours.	Previous operative procedures; haemorrhage; infection.	Arterio-venous aneurism of femoral vessels.	Operated upon in 1879.
2	II	Nicoladoni.	45 hours.	Prolonged operation; haemorrhage.	Spurious aneurism of right hypogastric and iliac regions.	Death might perhaps have been avoided by primary compression of the common iliac.
3	I	Kümmel.	12 hours.	Preoperative gangrene; haemorrhage.	Arrest of haemorrhage from one of a number of aneurisms.	Patient in desperate condition before operation.
4	I	Gouley.	21 days.	Pyaemia.	Diffuse aneurism of the ext. iliac.	Operation in 1871.
5	II	Fluhrer.	7 days	Nephritis.	Aneurism of the external iliac.	The increase in blood-pressure may have lighted up a chronic nephritis.
6	II	Smith.	11 days.	Peritonitis (?); thrombosis; gangrene.	Ilio-femoral aneurism.	Ligation of the common iliac not alone responsible for the result.
7	II	Bryant.	3 days.	.....	Aneurism of the external iliac.	Very brief report. Cause of death not given.
8	II	v. Büngner.	5 days.	Haemorrhage; gangrene.	Aneurism of the sciatic artery.	The haemorrhage and gangrene might perhaps have been avoided by preliminary occlusion of the common iliac.
9	I & II	Körte.	37 days.	Haemorrhage; ligation of abdom. aorta 37 days after lig. of common iliac.	Ruptured aneurism of the common iliac.	Death occured one hour after ligation of the aorta.
10	II	Maynard.	8 days.	Extravasation of blood; preoperative gangrene of scrotum; diarrhoea.	Diffuse iliac aneurism.	Death not attributable solely to ligation of the common iliac.
11	I	Czerny.	5 months.	Miliary tuberculosis.	Slight haemorrhage in course of operation.	The ligation of the common iliac not responsible for the death five months later.
12	I	Trendelenburg.	3 hours.	Haemorrhage.	Dissecting aneurism of common iliac.	
13	II	Cranwell.	36 days.	Arteriosclerosis; sacral decubitus; gangrene; amputation.	Aneurism of ext. iliac and femoral arteries.	The amputation wound showed no tendency to heal. Death too long after operation to be attributed to ligation of common iliac.
14	II	Judd.	2 days.	Patient did not rally from operation of 3 hours' duration.	Aneurism of external iliac.	Difficult and prolonged extraperitonaeal ligation of the common iliac.

Concerning Group II, he remarks:

"A just appreciation of the results of these 15 cases would give the following conclusions: recoveries, five; permanently cured, one (Mott); temporarily, two (Salomon, Peace); unknown, two (Hey, Garviso); died, ten; fault of ligature, one (Crampton); condition of patient most unfavorable at time of operation, two (Syme, Van Buren); intercurrent disease unconnected with operation, one (Stone); connected with operation, three (Stevens, Jones, Wedderburn); local disease due to operation, one (Stephen Smith); cause of sinking and death uncertain, one (Goldsmith); attributed to operation, one (Lyon).

"The results of the operation of deligation of the common iliac artery for aneurism, as compared with the same operation upon the external iliac, is worthy of notice. In 95 cases, which I have examined, of ligation of the latter artery for aneurism, 69 recovered and 26 died, being a mortality of about 27 per cent, or less than half the mortality of the same operation for the same disease when performed upon the common trunk. The cause of death in 11 cases, or nearly one-half, of ligation of the external iliac for aneurism was mortification of the limb, presenting a striking contrast with the same operation upon the primitive iliac, in which there was but one instance in eight cases."

Dreist collected 52 cases from the septic era; 17 of these are in Group I; 14 died; mortality 82.35 per cent; 35 are in Group II; 26 died; mortality 74.29 per cent. From the antiseptic era (since 1880) he collected 10 cases; five in Group I, with three deaths; mortality 60 per cent; five in Group II, with three deaths; mortality 60 per cent.

I have compiled for the hundred years from 1812 to 1912 (Groups I and II) 76 cases of ligation of the common iliac. Hence three-quarters of a case per year since the first ligation by Gibson. Forty-six of these were operated upon prior to 1880 (septic era); 30 subsequent to that year.

Sixteen are in Group I; of these three recovered; mortality, 81.3 per cent. Sixty are in Group II; recovered, 25; mortality, 58.4 per cent. Of the 30 cases, Group II, of the septic period, 21 died; mortality 70 per cent. Of the 30 cases, Group II, of the antiseptic period, 14 died; mortality, 46.6 per cent.

Analysing the 14 fatalities since 1880 (*vid.* Table D), we find that in three cases only (Fluhrer, Bryant and Judd) could death be attributed solely to the ligation of the common iliac artery. In all the others there were serious complications, sufficient to account for the fatal termination. In Fluhrer's patient nephritis is given as the cause of death. In Bryant's, no cause is assigned; the report, however, is very brief. Judd's patient did not rally from the shock of the prolonged (three hours) operation. The mortality, therefore, in the uncomplicated cases is at most 10 per cent. Possibly it is only 3.3 per cent.

Epicrisis.

From the critical consideration of the cases collated in this paper we may, I think, conclude that the uncomplicated ligation of the common iliac artery is not likely to be followed by gangrene, the percentage being from 3.3 to 6.6 instead of 33.3; and that the mortality, contrasted with 60 per cent as estimated by Dreist for Groups I and II, is at most 10 per cent and probably not more than 6.6 per cent; or it may even be as low as 3.3 per cent.

The data are too meagre to justify an expression of opinion as to function, my patient being the only one observed for sufficient time. In this man, although there may be no visible signs of disturbed circulation, the fact that he is unable to walk further than a very short distance without cramp-like pain would seem to indicate that the impairment of function should be attributed to ischaemia of the limb.

In Clark's case, at nine months, the function seems to have been good. His patient was only 26 years old.

Notwithstanding the low mortality and the infrequency of gangrene consequent upon ligation of the common iliac for aneurism, the operation is not an ideal surgical procedure, and chiefly, in my opinion, for the reason that it cuts off the direct blood supply from the internal iliac.

Furthermore, the operation under consideration does not invariably cure aneurism. In the eleven cases of recovery [5] since 1880, without gangrene, and in which the operation was performed for aneurism, there was recurrence in one after seven months (Gillette), and of the six cases in Stephen Smith's collection, one recurred after fourteen months (Peace). It is possible that in other cases, also, recurrence would have been noted had the patients been observed for a longer period.

In extirpation of the aneurism we have a means of curing it. But that this procedure, which has rarely been resorted to in the case of aneurism of the external iliac artery is less dangerous, or less or more liable to be followed by gangrene, we do not as yet know. We might, however, predict that the function of the limb would be less impaired by the excision of the sac than by the ligation of the common iliac, because the former operation does not interrupt the circulation in the internal iliac artery.

In the excision of such an aneurism the external iliac would have to be ligated twice and if the lower ligature had to be placed below the deep epigastric and circumflex iliac arteries, the limb would be deprived of the services of these important anastomotic channels. We know, as I have said, but only in a general way, that ligation of the external iliac is much more

likely to be followed by gangrene than is ligation of the primitive stem.[33] Furthermore, the enucleation of an aneurism may be difficult and attended with the danger of wounding important veins and of thrombosis of vessels not actually cut or torn.

The ideal operation, as it seems to us at present, is one which causes only so much disturbance of the circulation as is necessarily incident to a spontaneous cure of the aneurism, namely its obliteration.

This is precisely what the Matas operation contemplates. The vessels which are given off from the sac must, in the course of cure, be occluded at their origin, and, presumably, to the first collateral branch.

I should suppose, however, that the danger of gangrene after the Matas operation would be at least as great as from ligation of the afferent artery immediately above the aneurism, were it not that the former procedure promptly relieves the patient of the tumor and the pressure which it exerts, whereas after ligation many months may be required for the absorption of the aneurism. Also in favor of undertaking to perform the Matas operation, even in cases which might prove to be unsuitable for it, is the fact that the precise state of affairs becomes investigated and such endeavor not infrequently may result in the finding of a hole in the artery, as in the case of Balch and Murphy,[34] the closure of which will suffice to cure the spurious aneurism. In such case, although the performance of the Matas operation is not indicated and, indeed, not possible, the result will justify the means.

In other words, the condition of the patient permitting, a thorough operative investigation should be made in all cases of aneurism or wound of the external iliac artery.

A fatal termination might have been avoided in a very considerable number of the cases of ligation of the common iliac if this vessel had been temporarily compressed and the precise condition investigated at the first operation.

I should not suppose that the preservation of the vaso vasorum would be important for the prevention of gangrene which, when it occurs, follows operation too quickly for these little vessels to have become serviceable. Maintenance of their integrity might possibly be of value for the preservation of function.

In what has been said, I have not had in mind either the restorative or reconstructive operations of this eminent surgeon. The former of these procedures may have a sphere of great usefulness in saccular and arterio-

[33] It would be interesting to try to determine by careful study of the cases, the explanation of this well established fact. It is my opinion, as already indicated, that it may be found in the situation of the aneurism.

[34] Boston Med. & Surg. Jour., 1908, Dec. 24, p. 860.

venous aneurisms, but I have not regarded with much favor the attempts which have been made to reconstruct arteries from the diseased wall of the aneurism. I believe it will be found that modification of the Matas operation may be indicated in many cases, possibly in a considerable proportion of them. It may, for example, not always be desirable, even when possible, to approximate the intimal surface throughout. In some cases it may seem better to split the sac longitudinally or otherwise, in one or more places, and to close the several parts of the sac independently. In others the sac may lend itself in part or in toto to excision naturally and without injury to outside vessels, and when this is the case enough of the sac might be left on the stump of the various arteries to enable the surgeon to close their orifices, from the intimal side, if it should seem advisable to do so, with one or more circular stitches or rows of suture.

In cases in which no advantage is to be gained by leaving the sac, it might, perhaps, better be removed. It should, in my opinion, never be drained merely for the sake of drainage. It is conceivable that in rare instances it might have to be packed for the control of haemorrhage, as, for example, in a case of spurious aneurism, when, if the patient were exhausted, it might be unwise to attempt to check every oozing point.

In the case of subclavian aneurisms I am still of the opinion that excision when feasible may prove ultimately to be the best treatment in selected cases. When the sac lends itself easily to enucleation without danger to the contiguous vessels, there should be no added danger attending its extirpation. All of the arteries arising from it can be ligated as they present themselves in the course of the dissection—arteries which in the performance of the Matas operation would either have to be exposed and temporarily clamped, or occluded, less advantageously perhaps, and at times with difficulty in the presence of haemorrhage, from within the sac. In many instances the operators have been greatly embarrassed on opening the sac by haemorrhage from vessels which were not or could not be clamped from without.

Of the cases not located on the extremities, those lend themselves best to the performance of the Matas operation in which all of the arteries leading from the sac can be temporarily clamped outside of it. Now when all of these have been exposed sufficiently for clamping it is not quite clear to me why their permanent closure should be deferred until the sac shall have been opened.

A few days ago, in operating upon an aneurism of the dorsalis pedis artery, the afferent and efferent orifices were less than 1 cm. apart and were easily approximated without tension. An end-to-end suture which in some situations and under certain conditions would be unquestionably indicated

was not considered worth while, and it would have seemed absurd not to have excised the readily enucleable sac.

Each aneurism presents its special problems which it may not be possible to solve altogether until the operation has neared completion.

As a general proposition, I should be disposed to ligate permanently, just outside of the sac, all arteries which in the natural course of performance of the Matas operation would be clamped temporarily. And, inasmuch as all arteries leading from the sac should, when feasible, be under the control of clamps (when not controllable by the elastic bandage) before the sac is opened, are there good reasons for not removing under these circumstances a sac which has, in the process of the exposure of the arteries for clamping, become almost enucleated?

I have been unable as yet to convince myself that arteries which have been temporarily occluded in close proximity to the aneurism might not better be tied at once and divided, for thus the arteries still to be sought with the object of temporary occlusion in view become more readily accessible. And when these secondary arteries have been clamped why not ligate and divide them also for the same reason, and so on until all of the arteries, which in the course of the Matas operation would be temporarily occluded, have been tied off?

So much of the sac as, by this time, may have been dissected out, might, it seems to me, be removed with advantage unless it could serve some special purpose by being left.

And even in the cases in which the Matas operation seems to be clearly indicated and in which temporary compression of the main artery above and below the sac is contemplated, the dissection necessary for an exposure of this vessel which would be ample for the simple ligation might be insufficient for its temporary occlusion with the necessarily somewhat cumbersome clamps designed therefor.

In the case of popliteal aneurisms especially, and of aneurisms so situated that their blood supply can be completely controlled by tourniquet the Matas operation plays an important rôle. In brief it is particularly applicable to the treatment of such aneurisms of the extremities the extirpation of which might be attended with greater interference with the circulation. In other situations, in the case of easily enucleable aneurisms, the danger of haemorrhage should ordinarily be less with extirpation than with the Matas operation.

Dr. Matas has with great courtesy written me concerning the cases of aneurism of the external iliac and ilio-femoral arteries which have been treated by his method and I await with interest their publication in detail. No one, I am sure, can be more eager than he to determine the precise indi-

cations for the operation so brilliantly conceived by him or to suggest modifications of it should they seem to be clearly indicated.

It is undoubtedly the duty of every surgeon to familiarize himself by much practice on animals with the treatment of wounds of the heart and largest blood vessels, vein and arteries, for otherwise he might be unable to cope properly with an emergency which, any day, may confront the active practitioner of this art. I would recommend the making of fistulae between the aorta and vena cava, the vena cava and portal vein, and between the innominate vessels. Also the practice of the end-to-end suture and the implantation of vessels.

One of the chief fascinations of surgery is the management of wounded vessels, the avoidance of haemorrhage. The only weapon with which the unconscious patient can immediately retaliate upon the incompetent surgeon is haemorrhage. If he bleeds to death, it may be presumed that the surgeon is to blame, whereas if he dies of infection, or shock, or from an unphysiological operative performance, the surgeon's incompetence may not be so evident.

A CASE OF ILIO-FEMORAL ANEURISM EXEMPLIFYING THE VALUE OF THE PRELIMINARY PARTIAL OCCLUSION OF AN ARTERY IN THE TREATMENT OF ANEURISM[1]

Excision of an ilio-femoral aneurism three weeks after preliminary partial occlusion of the external iliac artery.—Surgical No. 31928. W. C., colored man, aged 40, admitted to The Johns Hopkins Hospital April 10, 1913. Eleven months before admission, patient noticed a dull pain on stooping and found a small, pulsating lump in the left groin which has steadily increased in size. Five months ago the limb began to swell.

Examination.—The patient is a tall, muscular, robust negro. The thorax is negative except for a systolic blow over the left interscapular region. Superficial blood vessels are sclerotic. Blood pressure is 130. The abdomen is distended; there are tortuous superficial veins over left abdomen, and oedema of the skin to the level of the twelfth rib. Over the aorta, which seems unusually large, a distinct bruit is heard. The left leg is enormously swollen from groin to toe, and so hard that even on forcible pressure there is barely a suggestion of pitting. The entire thigh seems to throb with each pulsation, and the skin of the whole extremity is very much darker than on the opposite side. In the region of the groin is a great pulsating expansile swelling which extends from near the symphysis pubis to the anterior superior spine of the ilium, and from a line joining the iliac spines of the two sides to a point about 10 cm. below Poupart's ligament. The precise outlines of the aneurism cannot be determined, on account of the great swelling all about it, except above, where it terminates quite abruptly. A thrill is felt over the tumor and a bruit can be heard from the abdominal aorta down to a point about 15 cm. below Poupart's ligament.

The measurements of the extremities are as follows:

	Right cm.	Left cm.
Thigh at level of gluteal fold	48.5	63
Knee, across patella	33.5	45
Calf of leg, 15 cm. below knee-joint	31.5	40.5
Ankle, 2 cm. above internal malleolus	20	26.5

Believing that the danger of gangrene in this case would be unusually great either from ligation of the external iliac artery, from excision of the sac, or from the Matas endoaneurismorrhaphy, indeed, from any method which would suddenly cure the aneurism, except possibly vessel transplantation, I decided to make a preliminary partial occlusion of the external iliac artery.

First Operation.—Partial occlusion of the left external iliac artery with an aluminum band. May 21, 1913: The artery was readily found. It was

[1] J. Am. M. Ass., Chicago, 1914, lxiii, 207-208.

abnormally large, very deeply situated and ran from behind forward instead of from above downward. The vessel was freed with two long blunt dissectors and lifted from its bed with two tapes, between which the aluminum band was curled about it. With the thumb and finger the band was rolled (tightened) until a thrill could be distinctly felt in the artery below it. The band was again rolled—tight enough this time to obliterate the thrill in the artery and the pulsation in the aneurism. A very faint, hardly perceptible pulse could still be felt in the external iliac artery between the band and the aneurism. Thus the vessel had been occluded to precisely the desired amount. The foot immediately became quite cold. Had the artery been totally occluded gangrene might have resulted.

After closure of the wound a faint bruit, now confined to an area not over 4 cm. in diameter, could be heard just below Poupart's ligament. There was no appreciable pulsation in the aneurism.

May 22d.—(Twenty-four hours after operation.) Circulation in foot has improved. Patient can move toes and ankle freely. He has some pain in the leg. During the night the toes were numb and insensitive to touch.

May 23d.—The swelling of the limb has decreased. The thrill extends higher over the aneurism and along the course of the external iliac artery than before the operation. The band is probably responsible for this.

I may remark here that the thrill has been an important guide to us in the conduction of our experimental and clinical work, for it indicates quite accurately the degree of constriction which has been attained. In the histories of our experiments we read, "Artery has been constricted to the thrill-point," or "thrill-points passed but pulse perceptible," or "thrill and pulse obliterated but lumen of vessel not completely closed."

May 25th.—Patient is free from pain. Sensation and temperature of the limb are normal. A previously much-dilated tributary of the long saphenous vein is no longer visible. There is a suspicion of pulsation in the aneurism.

June 6th.—The swelling of the limb has steadily decreased since the operation. There is a very faint but definite pulsation in the aneurism.

Second Operation.—Excision of the aneurism. June 7th: The skin having been disinfected with alcohol and tincture of iodine, the entire field of operation, including scrotum, penis, abdomen, gluteal region and anterior surface and sides of thigh were covered with a layer of very thin linen soaked in celloidin. A long vertical incision was made through the dried celloidin and linen over the greatest convexity of the aneurism. Before resorting to temporary occlusion of the common iliac artery an attempt was made to enucleate the sac to the extent which might prove feasible (1) in the hope that it might be unnecessary to complicate the operation by the dissection of the common iliac and (2) because I wished to note the condition of the circulation in the anastomotic vessels as well as in the femoral vein and artery. The tissues over and about the aneurism seemed to be abnormally vascular, many more clamps than usual being required to control the bleeding. Two large, flattened and apparently obliterated veins lay over the inner part of the sac. The epigastric and external iliac vessels had been dissected out and tied, and the enucleation of the sac, above and at the sides, bloodlessly executed, when I decided that much time would be saved by making temporary compression of the common iliac. This vessel was exposed

by cutting upward over the left rectus muscle in the line of the scar of the original incision. A broad tape was wound twice around the common iliac, twisted until the artery was occluded, and the twist maintained by a clamp.

The aneurism was found to terminate below in a broad funnel from the inner and posterior side of which a large artery, presumably the profunda, was given off. Just below the funnel-shaped dilatation of the femoral, this artery was divided between two ligatures and the sac dissected out from below upward. A cord-like stricture, later supposed to be the femoral vein, was cut across and dissected up with the sac. The external iliac artery, without change in its size, plunged abruptly into the sac at the upper part of its posterior surface. The aneurism was then split longitudinally from one end to the other and the clots rapidly evacuated. The wall was perfectly dry, not a single bleeding point being seen. The sac was found to extend deeply into the pelvis. It, undoubtedly, had pressed on the internal iliac vessels and their branches. The further liberation of the sac was very easily and swiftly carried out, not a single vessel being divided except by the final stroke of the knife which severed the proximal end of the external iliac vein. This vessel having been occluded and cut through in its peripheral part was not definitely identified until redivided. Altogether the operation was carried out in a bloodless manner.

The sutured wound was 45 cm. in length. It was closed without drainage except for one short cigarette of gutta-percha tissue. A silver-foil dressing was applied. After the operation the left foot and leg up to the knee were distinctly cooler than the right. A difference in the temperature of the two legs was observable until the fifth day.

On recovery from the anaesthesia the patient could move the toes and ankle freely. He stated that his foot felt numb, but he could locate accurately pin-pricks at every point except along the inner margin of the nail of the great toe, and could readily distinguish heat from cold.

June 11th.—First dressing. Wound healed throughout by first intention except for the drainage opening. Patient has been remarkably comfortable, requiring no morphine since the operation. The swelling throughout the entire limb has greatly decreased. There has been no distention of the abdomen, notwithstanding the transperitonaeal exposure of the common iliac artery.

July 16th.—(Nine days after operation.) Patient has been walking about for several days. He states that his leg is absolutely comfortable and rapidly gaining in strength. The entire limb is soft and quite natural. The circumference of the thigh measures 11 cm. less than before operation. Elsewhere the swelling has decreased proportionately.

November, 1913.—Patient writes enthusiastically of his present condition. He states that he observes no sign of swelling or loss of power or sensation in the left leg, and that he is able to do a hard day's work without unusual fatigue.

I have cited this case at such length because it seems to me to demonstrate quite convincingly that the employment of the metal band was not without avail. One might well perhaps allow a longer time for the establishment of the collateral circulation, but in this instance it was not possible to do so as I was to sail for Europe two days after the second operation.

PARTIAL, PROGRESSIVE AND COMPLETE OCCLUSION OF THE AORTA AND OTHER LARGE ARTERIES IN THE DOG BY MEANS OF THE METAL BAND[1]

At the meeting of The Johns Hopkins Hospital Medical Society, March 20, 1905, a brief preliminary report was made of the results of experiments in occlusion upon the abdominal aorta and other arteries of sixty-three dogs, conducted during the previous winter and autumn by Dr. W. F. M. Sowers and me.[2] During the following year these investigations were continued with the assistance of Dr. E. H. Richardson, thirty-nine dogs being operated upon. With the aid of a modified Brauer apparatus devised by Dr. Follis and Dr. Fisher we were able successfully to constrict the thoracic aorta both in animals and man. In June, 1906, at the meeting of the American Medical Association in Boston, attention was again called to our work, the results to date being given in merest outline.[3] During the following two years, the exigencies of the surgical clinic seemed to demand experimental investigation in another direction and hence only a little time was found for prosecuting the arterial work under consideration, although several problems which have arisen in connection with it we regard with unabated interest; and with the solution of these we are again concerning ourselves. In the meantime, however, a number of experiments have been made, and several animals which were for many months under observation have furnished additional facts worthy of record. The method of applying the band has been improved and modified and new instruments for rolling it devised. The full report of this work will probably be published during the year in The Johns Hopkins Hospital Reports.

The incentive to the work was the desire, experienced by so many surgeons of the past and present, to be able to occlude safely the abdominal aorta in the hope of curing thereby aneurisms of this vessel and of the common iliac arteries. I shall write later of the attempts of Dubois, Assalini, Bujalsky, Pirogoff, Luigi Porta, Cooper and Keen to compress gradually the abdominal aorta by means of specially devised instruments which, passed through an incision in the abdominal wall, carried a snare of silk, catgut or

[1] Received for publication January 14, 1909.
J. Exper. M., Lancaster, Pa., 1909, xi, 373-391.
[2] Johns Hopkins Hospital Bulletin, 1905, xvi, 346.
[3] Jour. of the Amer. Med. Assoc., 1906, xlvii, 2147.

metal which might at any moment be tightened or loosened at will. A fault common to all of the methods hitherto devised is seemingly an insurmountable one—the difficulty of preventing sepsis in the track of an instrument maintaining direct communication for days or even weeks with the air. A better method might, we thought, be one permitting, in each entre-act, complete closure of the wound. The material compressing the aorta should not be bulky nor endanger by its form or substance the adjacent parts; and it should admit of easy readjustment at subsequent operations, should they be indicated. Metal bands of silver and then of aluminium were employed with the hope that the amount of constriction might be regulated to a nicety at prospective subsequent operations as well as at the primary one. With the aid of an ingenious clock-maker, an instrument was devised to curl a metal strip, in perfect cylinder-form, about the vessel.

The tightening of the band is completed with the fingers; but in the early experiments, when the metal employed was too thick and the bands too broad, the aid of tweezers was required. We observed the first group of dogs with some apprehension, fearing that the edges of the band would cut the much constricted and powerfully pulsating aorta, and were considering ways to obviate, if necessary, this danger. On the twelfth day after operation a dog died of haemorrhage, the result of ulceration at the upper edge of the band. The experiments were thereupon discontinued for a while, to await results in the other dogs carrying aortic bands. Further cases of haemorrhage not occurring, we resumed, in a few weeks, the experiments. About three months later we investigated, at second operations and at autopsy, the resultant conditions and found that the aortic wall where the band had embraced it was, in each instance of complete occlusion, atrophied, being reduced in some cases to a film-like thinness. Notwithstanding these somewhat discouraging observations the experiments were continued as actively as time permitted in the hope that, with an improved technique, derived from greater experience, particularly with reference to precision in the determination of the degree of closure brought about as the rolling (tightening) of the band proceeded, the walls of the arteries might retain their vitality even in the case of complete arterial occlusion (*vide* Cases 27 and 28). By reducing the width and length of the band and the thickness of the metal, we were able with the fingers, and with ease, to occlude the artery to the extent desired. From the first experiment we have endeavored, in each instance, to roll the band as perfectly (as cylindrically) as possible, flattening of it being assiduously guarded against. To control with accuracy the amount of blood-flow under the band, the rolling must go on smoothly and under the perfect command of the operator. The thrills of various strength, the point at which the pulse disappears, are carefully noted in

the course of the act of constricting the vessel; and, finally, when complete occlusion is desired, the pulse being no longer distinguishable, the filling or not of the artery below the band, between it and a fine clamp placed central to the first distal branch is our only clue as to the patency of the artery.

With the use of silk or even silver wire such delicate manipulation and determination were found impossible, irrespective of the great danger of injury to the vessel wall from attempts to draw just a shade tighter a half-knotted thread which has constricted the vessel almost to the occlusion point.

At the time of my first report (March, 1905)[4] we stated that: (1) If applied tightly enough to interrupt completely the circulation, the band had usually caused atrophy and frequently complete absorption of the aortic wall. In such cases haemorrhage was invariably prevented by the formation of connective tissue enclosing the band. (2) Thrombosis had not been observed in a single instance, either in the cases of complete occlusion in which the arterial wall under the band was found so greatly thinned, or in those in which it had been absorbed. (3) In a few cases (*vide* No. 28) aortic walls drawn together so snugly that at autopsy water could not be forced through with a syringe were, on division of the band, found to be normal and could be easily smoothed out and the full lumen reestablished. But in these earlier cases of complete occlusion the aortic wall had almost invariably atrophied, having been so tightly constricted as to be deprived of its blood supply, and hence the "ideal obliteration" (reported the following year) by adhesion of the folded intima and the conversion of the constricted portion of the artery into a solid fibrous cylinder (*vide* Plate XXIX, 2*a*), could not have taken place. (4) The less snugly, the loosely and the very loosely applied bands might remain on the aorta, femorals and carotids for months without apparent injury to the walls of these vessels, either externally or internally. For example, the band after one hundred days would be seen shimmering brightly under a quite normal-looking peritonaeum, having caused, as a rule, little if any reaction, and could be as easily removed from the wall of the artery as when originally applied. (5) We were encouraged to believe that there might be a place in surgery for the partially occluding band, and reported its application to the common carotid artery in the human subject and the manifestation, thereupon, of slight brain symptoms which persisted for several months. In this case the band was rolled more tightly than intended. It might easily have been removed and reapplied but, as I stated at the time, our notions being somewhat vague as to the precise amount of constriction to be desired and being unable to determine accurately the blood pressure distal to the band we decided not to disturb it and to note results. On the appearance of the head symptoms

[4] *Loc. cit.*

I did not relieve the constriction, believing that they would probably disappear; furthermore, I was not perfectly sure that, rather than good, harm might not result from the release of the carotid.

Subsequently (in June, 1906), in the report made in Boston before the Section on Surgery and Anatomy of the American Medical Association, the following newly observed facts were emphasized:

1. The blood pressure in the aorta below the band is lowered in proportion to the amount of the occlusion. The rise in pressure below the band is, at first, rapid, but varies considerably in the different dogs. For example, in one dog, a rise below the band of ten millimetres (Hg. manometre) was noted in ten minutes, whereas, in another dog, two hours were required for a rise of fifteen millimetres. For the return of the normal pulse wave and of the normal blood pressure as many as seven months have been insufficient (*vide* history of Dog No. 96).[5]

2. Partially occluding bands produced, as a rule, no macroscopic alteration in the aortic wall under the band even after seven and eight months (*vide* Plate XXIX, 1). Under completely occluding bands the arterial wall had (to the date of the second communication referred to) usually atrophied and in the course of weeks or months been absorbed. *"When the lumen had been, perhaps, not quite*[6] *occluded, complete obliteration might result spontaneously with the conversion of the arterial wall embraced by the band into a solid cylinder of living tissue. This may,"* I stated, *"be considered the ideal closure of an artery."* Although this form of arterial closure had occurred only thrice in the long series of experiments, it might, I thought, be accomplished frequently, and ultimately the band might be applied with such nicety that, unaided, further, by the surgeon, a partial would be likely to proceed to total occlusion.

3. *"The Effects on the Spinal Cord and Its Coverings.*—The study of the spinal cords was entrusted to Mr. P. K. Gilman (later Dr. Gilman and member of my staff), who discovered, in a number of instances,[7] about three

[5] Since this statement was made we have had several opportunities to verify it, and have noted in a dog with partially occluding band on the thoracic aorta. after seven months, a difference of 30 millimetres or more in the pressure immediately above and immediately below the band. Of particular interest are the careful observations of Dr. Percy M. Dawson on the femoral and carotid pressures in Dog No. 96 of this series, reported below.

[6] We have not as yet learned to determine with the greatest precision the degree of arterial occlusion effected, nor am I convinced that in all of the cases in which the "ideal occlusion" has resulted (we have now five such observations) there may not have been, at the outset, complete obliteration of the lumen (*vide* history of Dog No. 27).

[7] These proved to be cases in which total or almost total occlusion had been made.

months after operation, a deposit of extradural fat about the cord below the site of the aortic band. In three cases the production of fat was so great that it filled, seemingly under considerable tension, the vertebral canal."

If these observations should prove to be correct, Mr. Gilman has made a discovery of wide significance.

4. That in the human subject I had partially occluded the innominate artery once and the common carotid four times.[8] In the case of a large popliteal aneurism I had employed the metal band to occlude completely the femoral artery. In the case of a woman asphyxiated to unconsciousness by an aneurism of the aortic arch, I had exposed, carefully and freely and without puncturing either pleural cavity, the heart and arch of the aorta, hoping to be able to encircle with a band the aortic arch between the regions of the innominate and left carotid arteries, but the aneurism was so extensive and the patient's condition so desperate as to defeat the earnest and prolonged endeavor to execute the procedure.

The Aluminium Band and the Manner of Its Application to the Artery

We have tested only two of the metals, silver and aluminium, with reference to their adaptability to the procedure under consideration. After a few experiments with the former it was discarded. The greater weight and value of the silver (there is great waste in its use) and the inconstant results obtained as to nicety in rolling, particularly after repeated boilings, are the principal factors which led to its disuse. The aluminium, usually purchased in sheets of about 25 degrees of thickness (American scale) should be cut, before being rolled down to the thinness desired, into strips of convenient length, and of width not greater than three quarters of an inch. If much wider, the strips warp inconveniently and have to be cut to waste in the selection of flat and regular parts for band material. It is well to stamp each strip with the numbers indicating the thickness of the metal and to have on hand a liberal supply of the various thicknesses from No. 25 to No. 46. The finest numbers we have used on the very small femoral and renal arteries of the dog. In the average dog for the abdominal aorta Nos. 34 to 35 are suitable, and for the thoracic aorta Nos. 33 and 34 we have used most frequently. In the human subject for the abdominal aorta below an aneurism near its bifurcation No. 33 sufficed, but ordinarily a heavier size would be required; for the common iliac No. 32 answered the purpose

[8] The aluminium band has now been successfully applied in man to the common carotid artery twelve times, and once each to the thoracic aorta, the abdominal aorta, the common iliac, the femoral, and the innominate arteries. These cases will be reported later in the Amer. Jour. of the Med. Sciences.

admirably; for the thoracic aorta Nos. 22 to 25 perhaps; for the common carotid we have almost invariably selected No. 33. The length of the band should be about that of the circumference of the full artery. The width varies from about 2 mm. for the renal arteries in the dog to about 1 cm. for the thoracic aorta and innominate artery in man. Plate XXVIII, 1, *b*, depicts a band suitable in width for the human carotid and for the average dog's abdominal aorta. The band in this illustration we should now regard as too long for its breadth by approximately one third. It is best to sterilize the aluminium only once. It may become too brittle for perfect rolling by repeated boilings. When rolled down on the artery enough almost to obliterate the pulse, a band of seemingly proper dimensions has rarely described more than two complete circles. The filing or "manicuring" of the band is of very great importance. It should be curved like a finger nail at the forward end and at the other cut precisely at right angles to its long axis. With a file the edges should be made perfectly smooth, but not sharp, and the rounded end symmetrical. A carefully filed band coils more easily both in the instrument and under the fingers, and, what is more important, is not likely to cut the artery. The aorta is the only vessel that I have seen cut itself on the band, and then, with the exception, perhaps, of two very young dogs or puppies, only when the band was badly filed or clumsily rolled, as in the early experiments, especially those in which forceps were employed to supplement the work of the fingers in tightening the too broad and too heavy bands at that time employed. Silk ligatures, even when occluding the aorta only partially, have in my experiments repeatedly cut entirely through the aorta, and without causing the death of the animal. They may leave in their wake various forms of diaphragm which more or less obstruct the lumen of this artery. I shall refer to a case of this kind depicted in Plate XXIX, 3 and 4.

The Band Curler.—The original instrument (*vide* Plate XXVIII) had, we soon discovered, three major faults. It was (1) too broad at the arterial end, (2) the band lacked anterior support as it was being pressed onward by the driving blade, *a* (magnified *a'*), and (3) the latter did not always engage the former, owing to the fact that it was too springy and was insufficiently linked to its fellow on which it glides. To remedy the tendency for the band to buckle forward, one was compelled to support it with the finger during the process of curling. This was occasionally a difficult and usually an awkward performance.

Plate XXVIII, 2 shows an improved and satisfactory band roller or curler. In the full length drawing the instrument is not loaded; in the abbreviated sketch the band projects from the end, half curled. The principal defects of the old instrument have been remedied in the new. Buckling

of the band is prevented by the boxing; the driving-plate cannot spring away from its fellow, and the width of the instrument has been sufficiently reduced to permit it to be passed freely between the closely given off branches of the abdominal and thoracic aortas. When the thinner bands are used it is sometimes necessary to give the faintest tip backwards to each of the two right-angled corners of the band to insure its engagement in the downward thrust of the piston or driving blade. After it has encircled the artery the band may, if its corners have been bent, be freshly squared with the scissors before being curled tighter by the fingers. This is not, however, necessary. The curler being armed with the carefully filed band of correct proportions, the plunger is made to engage the band and to force its convex end into sight before the instrument is passed under the artery. In Plate XXVIII, 1, the act of curling the band about the artery is shown, after the old manner, in its first stage. As the curling proceeds the instrument is gradually withdrawn. In arranging for the tightening of the band, its convex end should lie on the wall of the artery and be overlapped by the square end. With a very little practice one learns to avoid bending or flattening the band in the process of tightening it. The band should be long enough to encircle the artery in the expanded state of the latter and the metal should be sufficiently thick and wide to sustain the curl given it. If perfectly rolled the inside and outside circles of the metal touch each other at all points of the surface of contact and, in consequence, the cohesion force is greatest. The artery should be raised from its bed by two tapes held far enough apart to leave uncovered sufficient free space on the artery for the occupancy of the band. Traction on the upper tape should be made to interrupt the blood current and thus to reduce the size of the vessel. A band curler should be selected (we have, at present, four sizes of this instrument) which might make the metal describe a circle smaller than the distended or full artery but a little larger than the empty one; then, with the return of the blood current, the artery expands and may fill the band quite snugly.

After complete occlusion of the abdominal aorta the femoral pulse does not, usually, return for weeks or even months. And after incomplete occlusion of the thoracic aorta (Dog No. 96) the femoral pulse may be hardly discernible after seven months. The anastomotic circulation takes place through the vasa vasorum as discovered and so beautifully depicted by Luigi Porta,[9] and by way of the internal mammary and epigastric arteries as especially emphasized by Kast.[10] We have repeatedly observed the great increase in the vascularity of the abdominal wall, particularly on splitting

[9] Luigi Porta, Delle alterazioni patologiche delle arterie per la legatura e la torsione, Milan, 1845.

[10] Kast, Deut. Zeit. für Chirurgie, 1879, xii, 405.

the recti muscles but also in making mid-line incisions at operations subsequent to the one at which the band was applied.

Dog No. 2.—Large, savage, collie-like dog. *Operation I.* Morphia and ether.[11] November 4, 1904. Silver band, partially occluding the vessel, applied to the abdominal aorta below (?) the inferior mesenteric artery. Radicles of thoracic duct not injured. Pulse in femorals easily countable at end of operation, though much reduced in volume.

November 6, 1904.—Dog in good condition, rather dull, walks about without apparent weakness in hind legs. Tests such as running up stairs were not made.

November 10, 1904.—Apparently perfectly well. Is quite savage and threatens to bite when cage is entered.

December 8, 1904.—Vigorous femoral pulse but seemingly weaker than might be expected in so large a dog. Health has been perfect. *Operation II.* Morphia and ether. Complete occlusion of aorta about 1 cm. above the silver band by heavy black silk ligature. The silver band glistened through a very thin and apparently normal peritonaeum. It had excited little or no irritation. On coming out of ether the dog showed signs of unusual excitement. Respirations, 136 per minute. One hour after operation dog was able to climb a flight of stairs. The hind legs were, however, in spastic condition, flexed on the abdomen, at the knees and hips, and very much weaker than the fore legs.

December 10, 1904.—Dog is dull. Hind legs are dragged in walking but are not completely paralyzed. Movements still spastic.

December 14, 1904.—Is lively and seems quite well. Bladder and rectum function normally. Scratches himself with left hind leg without apparent weakness.

January 27, 1905.—Femoral pulses not yet definitely palpable but the arteries have become quite full.

February 1, 1905.—Femoral pulse faint and not countable.

February 20, 1905.—Fair pulse, countable.

March 6, 1905.—Found dead. Was not observed yesterday (Sunday). *Autopsy.*—A large flat cork causing intestinal obstruction is the cause of death. The silk ligature above the band has cut almost through the aorta, its track being apparently healed; part of the loop projects into a little cavity, with newly formed walls of connective tissue, adjacent to and in front of the wall of the aorta. A filmy substance, like decolorized blood clot, is adherent to the track taken by the ligature in its course through the artery. The aorta under the band is a little thinned. Its endothelial lining seems normal.

In the light of subsequent experience it seems probable that the thinning of the aorta may have been caused by the ligature applied so close above the band—by its interference with the circulation in the arterial wall.

Dog No. 6.—Black bitch, length 31 inches. November 19, 1904. *Operation I.* Closure of abdominal aorta with aluminium band 1 cm. in width.

[11]All the animals were anaesthetized in the same way preparatory to operation.

The pulse pressure in the left femoral artery as recorded by an assistant:

Before operation	150 mm.
After abdomen was opened	130 mm.
Band incompletely tightened	80 mm.
Tightening of band completed	20 mm.
After abdominal manipulations were ended	25 mm.
After closure of abdomen	30 mm.

The operators could not feel the aortic pulse below the band after it was completely curled, hence I have doubt as to the accuracy of the three observations on pulse pressure in the femoral artery made after the final tightening of the band.

November 21, 1904.—Femoral pulse doubtful. Dog ran easily on level and mounted the first steps of a flight of stairs without definite signs of weakness. Her hind legs gave out before the top steps were reached. Temperature forefeet, 70°, hind feet, 66°, Fahrenheit.

November 22, 1904.—Hind legs still weak. Sits down after slight exercise. Pulse in femorals doubtful. Surface temperature of hind-flanks, 95°; fore-flanks, 97°; pads of feet, hind 97°; front, 71°.

November 25, 1904.—Temperature axilla, 98.5°; groin, 95.5°. Hind legs less weak. Dog in good spirits. *Operation II,* 11: 30 a. m. Ligature of black silk obliterating aorta applied below the band. 3 p. m., bladder not distended. Bitch has showed no excitement since operation. Temperature, axilla, 96°; groin, 93° F.

December 13, 1904.—Slightly stiff in hind legs. Dog is dull and indisposed to walk much. We attributed the condition of the dog in part to one-half grain of morphia administered before operation.

December 14, 1904.—Movements in hind legs greatly improved. Dog walks with ease but is a little depressed and sits down frequently.

December 19, 1904.—Perfectly well and active.

December 28, 1904.—Well and active.

January 7, 1905.—Well.

January 12, 1905.—Well.

January 19, 1905.—Well and strong. Faint femoral pulse observed for the first time since the first operation performed two months ago.

January 23, 1905.—Femoral pulse definite.

February 1, 1905.—Femoral pulse countable but is still very small.

March 6, 1905.—Dog well but quite thin. Killed with ether. Femoral and thoracic conditions normal. On palpating aorta a small nodule is felt at site of ligature. The band is found directly in line of the aorta above the ligature and filling completely a new-formed connective tissue cavity. The arterial wall under the band has been completely absorbed and the aortic wall above the band is continuous with the new connective tissue which forms a strong capsule about the band. The capsule of fibrous tissue fits the band so closely that no blood has escaped from the patulous aorta above into the space between the band and the connective tissue which enclosed it. The arterial lumen just below the band has been obliterated by the silk ligature which has cut entirely through the arterial wall and is enclosed in a hard nodule of connective tissue.

Dog No. 20.—Small puppy, male. December 10, 1904. 11 a. m. *Operation.* Aluminium band applied above the inferior mesenteric artery. In exposing the artery the sigmoid flexure was pulled to the right. The band had been cut too long. It rolled beautifully to a certain point and then, before the aortic pulse could be obliterated the metal cylinder began to flatten. The pulse then became entirely obliterated but some sort of pulse-shock could be felt for a distance of 1 cm. or more below the band. 1: 30 p. m., dog runs about, but his hind legs are very weak, though not completely paralyzed.

December 19, 1904.—Hind legs stronger.

December 20, 1904.—Dog does not seem well. Is quite thin and disinclined to walk. Can, however, stand and uses his hind legs in walking fairly well.

December 23, 1904.—Not so well.

December 26, 1904.—Quite ill.

December 27, 1904.—Dead.

Autopsy.—The abdominal wound had opened down to the peritonaeum but was well sealed by omentum and the subperitonaeal flap of fat. There is no peritonitis. The portion of the ileum lying in the pelvis, and the sigmoid flexure exhibit punctate haemorrhages in the fat along the vessels. The sigmoid flexure is particularly haemorrhagic and probably the cause of the bloody fluid in the pelvis. There is some blood escaping from the anus. The jejunum, at a point near the aorta where it may well have been pressed upon by the retractors and gauze, is also indurated and dark. The bladder is empty. The band has excited very little reaction. The peritonaeum and fat over it are still ununited.

Dog No. 27.—Small, black puppy. December 26, 1904. *Operation.* A very broad band (7 mm. in width) was placed on the aorta about 1 cm. below the inferior mesenteric artery and rolled by tweezers until the demonstration of a pulse below the band was questionable. We attempted in this case, prior to the application of the band, to produce occlusion by silver wire wrapped several times about the artery and over a small copper rod (the rod to be afterwards withdrawn), thinking that the size of the lumen might in such cases be definitely regulated by the use of rods of various sizes. After several trials we were convinced that the liability of injury to the artery was too great, at least much greater than with the employment of the band. The wrapping of the wire was also troublesome. Hence the project was abandoned.

December 28, 1904.—Walks fairly well but has definite weakness in hind legs. Has fluid stools which contain a few drops of blood.

January 5, 1905.—Weak and emaciated. A very small, not countable, femoral pulse has developed. Dog uses hind legs a little better.

January 23, 1905.—Is very feeble and thin. Isolated in cage.

January 27, 1905.—It is possible today for the first time to count the femoral pulse; it is still very small.

February 13, 1905.—Condition practically unchanged.

February 20, 1905.—Seems a little better. Femoral pulse still very small, but countable.

February 23, 1905.—Improvement continues. Femoral artery feels fuller.

April 10, 1905.—Dog is very thin and has the mange. Etherized. A very faint femoral pulse was demonstrable on dissection of the artery, but through the skin it was not definitely palpable. Dog killed.

Autopsy.—Peritonaeal cavity normal.

The aortic band shimmers quite clearly through the peritonaeum, but about 1 cm. below the band is a very delicate cicatrix. The aorta was split to the band from both ends and the band itself divided. The vessel is entirely obliterated and the length of the obliterated portion corresponds exactly to the width of the band. The portion of the aorta enclosed by the band *has become converted into a solid fibrous cord* (*vide* Plate XXIX, 2, *a*). Outside the band is a peculiar, soft, yellowish-white material, about one drop in quantity, resembling aleuronat. The hard, white, living cord, into which the occluded portion of the aorta has been converted, is 2 mm. in diameter. The band, an unusually broad and thick one, had been in place three and one-half months and might, without doing harm, have remained indefinitely. The form of the fibrous cord, so exactly cylindrical, under the band, is evidence that perfection in curling may be accomplished even with tweezers. Without especial effort to bring it about we have in five instances obtained this ideal form of obliteration—four times in the aorta and once in the renal artery—and always in cases in which the completeness of the closure was in doubt at the time of operation. This case should be contrasted with Case No. 28, that of a small puppy whose aorta, though of intention completely closed by the band, was not found converted into a fibrous cord under the metal. To our surprise, it presented no internal adhesions whatever on being laid open, although so tightly constricted that not a drop of water could be forced through this portion of the vessel while the band was in place. The foldings of the aortic wall under the band could be smoothed out so completely that no trace of them remained, nor was there any abnormality of the wall to indicate that a band had been applied. We must bear in mind that in Dog No. 28 only twenty-two days had elapsed from operation to autopsy, whereas in the cases cited of fibrous cylinder formation, the dogs had carried their bands for several months.

Dog No. 28.—Small, black puppy, male. December 26, 1904. *Operation.* Aluminium band rolled (with tweezers) until pulse seemed to be obliterated.

December 28, 1904.—Dog seems fairly well, but marked weakness and stiffness in hind legs.

January 7, 1905.—Dog cross and disinclined to respond to attentions. Hind legs possibly a little less stiff.

January 12, 1905.—Slight improvement noted.

January 17, 1905.—Dog looks badly. Is greatly emaciated. Indisposed to move and hence the power in hind legs was not tested.

January 18, 1905.—Great emaciation.

Autopsy.—Peritonaeal cavity normal. Band shimmers through a perfectly normal-looking peritonaeum. No trace of peritonaeal or other scar over band. The healing about the band is the most absolutely perfect that we have as yet seen.

With a syringe connected to the aorta above the band we are unable to force water through the site of obstruction. On removing the band we find, to our surprise, that not only could the point of a scissors readily be passed through the constricted part but that the aortic wall under the band could be so perfectly smoothed out that not a trace of the foldings or wrinklings of the lining remained. Nor was there apparent the slightest thinning or alteration in the wall of the vessel at the site of the band. We have not as yet had the time to complete experiments undertaken with a view to accounting for the difference in the condition of the aorta at the site of constriction in the cases (Nos. 27 and 28) referred to.

Dog No. 30.—Medium-sized collie bitch. December 27, 1904. *Operation I.* Aluminium band tightened until the pulse was greatly reduced but not apparently obliterated. There was sufficient pulse just prior to the final tightening to give a faint thrill.

December 28, 1904.—Dog convalescing normally. Uses hind legs quite well. No definite signs of weakness in them.

January 7, 1905.—No weakness in hind legs.

January 19, 1905.—Dog very well. Femoral pulse not yet distinguishable.

January 23, 1905.—Operation II. 11 a. m. There were a few adhesions of omentum in the neighborhood of the band, which prevented the metal from shimmering in the usual manner through the peritonaeum. Pulse below the band is feeble but perfectly definite. When the pulse just above the band is obliterated with the finger the pulse below the band disappears. We concluded consequently that the band had not completely closed the lumen of the aorta. Ligation with heavy black silk 3 or 4 mm. above band. Much to our astonishment the pulse, easily appreciable by finger, reappeared below the band in less than 30 seconds after the aorta was ligated. It seems almost inconceivable that a ligature applied so close above the band should have had such a marked influence on the pulse below it. We have made this observation in a number of cases in which we were quite sure that no vessel of a size to be appreciated was given off from the aorta between the ligature and the band.

The almost immediate reappearance of the pulse after the application of the ligature indicates that the anastomotic circulation was already quite well established, for a pulse large enough to be appreciated by the finger has not been observed by us before the termination of the operation, after complete closure of the aorta in one act. We have, however, noted that within a minute after ligation of the abdominal aorta a faint pulse below the ligature can be *seen* (not felt), provided the aorta is cut open.

January 23, 1905.—3 p. m. Dog runs about. Weakness of hind legs not apparent.

January 24, 1905.—A very faint femoral pulse can be felt very high up on the femoral arteries. No weakness of hind legs.

January 27, 1905.—Pulse more easily felt but still feeble.

February 1, 1905.—Femoral pulse can be counted. The artery is not full.

February 20, 1905.—Artery much fuller. Pulse stronger. Dog quite thin.

March 10, 1905.—Femoral pulse still small. Dog is thin but looks well. Ether administered. Abdomen opened. Small indurated area about the ligature and the band. A definite pulse below the band is promptly shut off by pressure immediately above the band and at higher points, as noted in history of Dog No. 6. A ligature was applied about 3 cm. above the band and tests for a pulse below the band were made for three minutes but it had not returned in this period of time. The dog was then killed. Above the ligature the aorta was entirely occluded in a conical manner. The ligature lies in a small cavity lined with granulations. Below the band the aorta is closed off by a small transparent film. The band lies in a connective tissue cavity and contains merely a film of opaque secretion. The aortic wall under the band has consequently been entirely absorbed. Between the two cavities a piece of aorta 13 mm. in length is felt with a partly organized clot which is translucent except for a red dot about 1 mm. broad, in its center.

It is evident that at the first operation I was probably mistaken in believing that the artery was not obliterated by the constricting band. It would, a priori, seem reasonable to presume that a band though not altogether occluding the artery, might, nevertheless, so greatly interfere with the circulation of its wall as to lead to necrosis, but the findings in Dog No. 28 would seem to make such a view untenable. It seems, however, not unlikely that the necrosis of the wall of the aorta may not have supervened until at the second operation the ligation with silk a few millimetres above the band was made. If this were the case it may be that our impression that the pulse had not been obliterated by the band at the first operation was correct.

Thoracic Aorta Partially Occluded by Aluminium Band.—Dog No. 96.—Medium-sized Newfoundland bitch. May 22, 1906. *Operation.* Assisted by Drs. Richardson and Gilman. Lungs inflated during the operation through tracheotomy tube. Incision through seventh interspace. Ribs separated as usual with self-retaining retractor. Exposure of aorta very satisfactory. Aluminium band, thickness No. 32, width 6 mm., applied just above highest point of diaphragm. Band was tightened until a continuous thrill below the band was produced.

May 24, 1906.—Slight stiffness in hind legs.

May 25, 1906.—Improving; takes milk. Femoral pulse doubtful.

May 27, 1906.—Cheerful; runs about freely. Percussion reveals no thoracic signs. Chest not auscultated.

June 1, 1906.—Dog is lively and well.

June 3, 1906.—I went to Boston.

June 11, 1906.—On my return from Boston today dog was reported well. I did not visit her.

June 14, 1906.—On visiting dog surprised to find that she is emaciated, low spirited and very weak. Lies in corner of kennel unless aroused. The keeper states that, suddenly, two nights ago the dog became paralyzed. He assured me that she was perfectly well the preceding day. Has made no observations as to her stools, urine or feeding. I placed her at once in a separate room for observation. Find that she can raise herself on hind legs and totter about with hind legs stiff and held apart. Power in hind legs quickly becomes completely exhausted.

June 15, 1906.—Better. Takes milk and eats a little.

June 16, 1906.—Improving. Has some appetite and a stronger gait. The femoral artery is fairly full but a pulse is not palpable.

June 18, 1906.—Stronger and in fairly good spirits. Is as lively as hind legs permit but still has difficulty in getting in a standing position; but when balance has been obtained runs about quite well, but for a few moments only, the hind legs weakening rapidly, then a few steps alternating with dragging. Femoral arteries full and quite tense but no pulse is as yet discoverable although carefully palpated for by several observers.

June 19, 1906.—At times there seemed to me to be a faint pulse in the femoral artery. Dog much livelier, eats better and gait is improved. She still experiences considerable difficulty in raising herself upon her hind legs, and after running five or six seconds flops down behind. She is up again immediately and again collapses as to hind legs. At no time have the stools been bloody or tarry. There has been no evidence either of retention of urine or difficulty in micturition. The dog is to be kept all summer under careful observation.

December 21, 1906. Since the last note the dog has been well but is still weak in the hind legs. No observations of especial interest were made during the summer. Careful examination by Drs. Sowers, Watts and myself determine that a femoral pulse is present but not easily countable, although it is now seven months since the operation. Only the lightest pressure of the fingers can detect this femoral pulse. Ether is administered and the dog brought into the surgical amphitheatre for demonstration to the class. The over-pressure box of Drs. Follis and Fisher was successfully employed throughout the observations which follow. On opening the chest the left lung and pleura were normal. The band is clearly seen shimmering through the thin and normal-looking pleura covering it. A very pronounced thrill is felt below the band on the thoracic aorta, just as at the termination of the first operation, hence our belief that the artery had suddenly closed about three weeks after the first operation and during my absence in Boston is proved to be incorrect. Dr. Percy M. Dawson then made the following observations upon the blood pressure in the carotid and femoral arteries.

"Upon the circulation of this animal observations were made in the physiologic laboratory and were reported as follows:

	Maximum pressure	Mean pressure	Minimum pressure	Pulse pressure
Femoral	116	96	88	28
Carotid	160	113	83	77

"These figures should be compared with values obtained in normal animals,[12] namely,

Femoral	188	120	95	93
Carotid	162	122	103	49

"The pressure curves were also obtained and showed a total disappearance of the dicrotic elevation from the femoral pulse whereas in normal animals the dicrotic is more marked in the femoral than in the carotid artery so that hyperdicrotism is more readily obtained in the former than in the latter.[13]

"All these changes are to be attributed to the constriction due to the band and are in complete accord with the unpublished experiments performed in this laboratory in which the aorta was partially occluded for the purpose of studying the relation of the carotid and femoral pulses.

"Considerable variations occur in the velocity of the pulse wave in different dogs. Nevertheless it is safe to say that a velocity of only 556 cm. per second as was found in this animal, owes its small value to the aortic constriction."

Dr. Richardson and I, by the Huertle method with hypodermic needle, observed, much to our surprise, that whereas the manometer registered 126 mm. above the band, it registered only 94 below it. *It seems remarkable that after so long a period (approximately seven months) there should be such a difference in the blood pressure above and below the band.* Just before death the aorta was completely divided below the band to determine the degree of patency of this vessel at the constricted point. The heart pumped through the band a small stream as large, perhaps, as that furnished by the human radial artery.

Autopsy.—There is a very great difference in the size and thickness of the thoracic aorta above and below the band. The wall of the artery above the band appears to be twice as thick and much stiffer than the arterial wall below it. There is also great dilation of the artery above the band. There are no visible calcareous plaques. On cutting through the artery and band in the usual way, the probe point of a scissors being passed into the lumen of the vessel, there is found to be no adhesion between the folded surfaces although, until the artery is spread quite flat, the foldings and creasings of the intima are evident. Were it not for the presence of the band which reveals its form from within by pressure on the wall of the artery from

[12] Amer. Jour. of Physiol., 1906, xv, 244.

[13] Amer. Med., 1906, i, 152.

without it might be difficult if not impossible to determine with the naked eye differences so far as the free surface of the intima is concerned, below and beneath the band. The lining of the aorta under the metal seems perfectly normal, as indeed does the entire thickness of the arterial wall. The spinal cord was excised by Dr. Gilman in my presence. As to the extradural fat formation in this case a report will be made later.

EXPLANATION OF PLATES.

Plate XXVIII.

1. Drawn in 1905. The original band roller in the act of curling a metal strip about an artery; *a*, the tip of the driving blade enlarged; *b*, the metal strip; *c*, the band slightly tightened with the fingers as when a degree of incomplete occlusion is desired. The proportions depicted are those observed at the time the drawing was made. We should now regard the length of the metal strip as about one-third too great for its width as well as for the size of the artery represented.

2. The improved band roller—the size usually employed in the experimental work. The instrument shown in full length is unloaded. In the abbreviated cut the band is about to be expelled from the roller. This band is broad enough for the abdominal aorta in man, and the diameter of the circle is too short for a vessel requiring such a broad band.

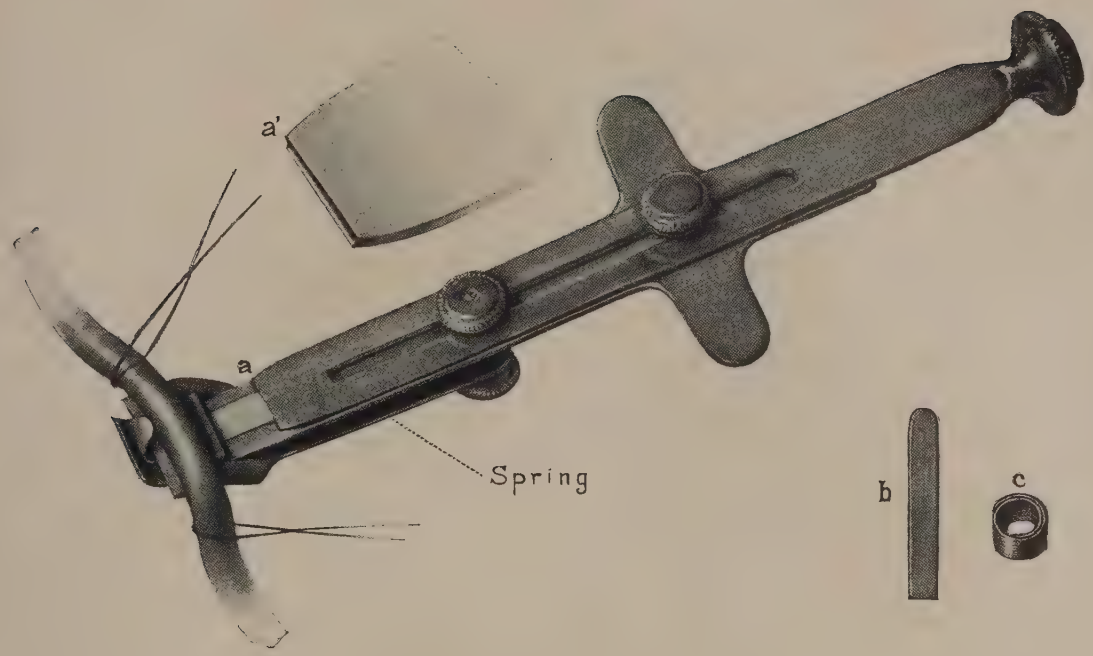
Plate XXIX.

1. Aorta of dog after partial occlusion by band for one month. The band (*b*), in outline, is seen through the vessel's wall. 2. Aorta of Dog 27 converted into a solid cylinder (*a*), the band (*b*) having embraced the artery for three and one-half months.

3 and 4. An aorta about which a partially occluding ligature of silk had been placed. In 4, the wall of the artery is divided anteriorly only enough to expose the diaphragm formed in the track of the ligature and perforated by two holes, *a* and *a'*. The silk ligature, at *b*, is more plainly seen in 4, in which the diaphragm has been divided as far as and into the anterior perforation.

Plate XXX.

The kidneys of a dog six months after the application of an occluding band to the renal artery of one of them. The band, spread out, lies *in situ* under the right renal artery which had become converted into a solid cylinder at this point, but was collapsed both proximal and distal to the occluding metal. Contrast the renal arteries of the two sides.



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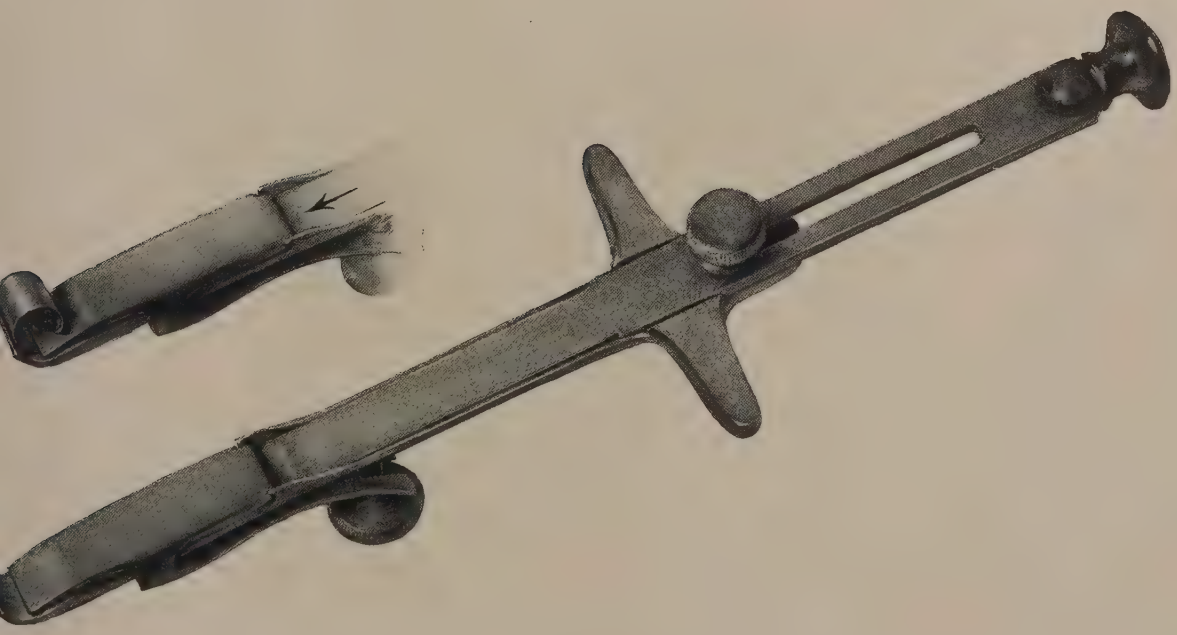
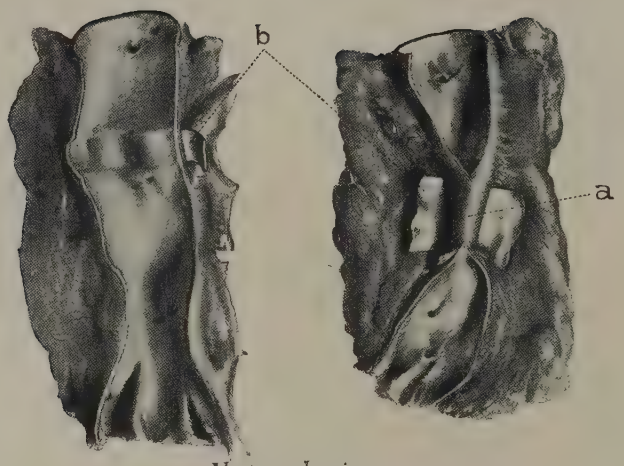


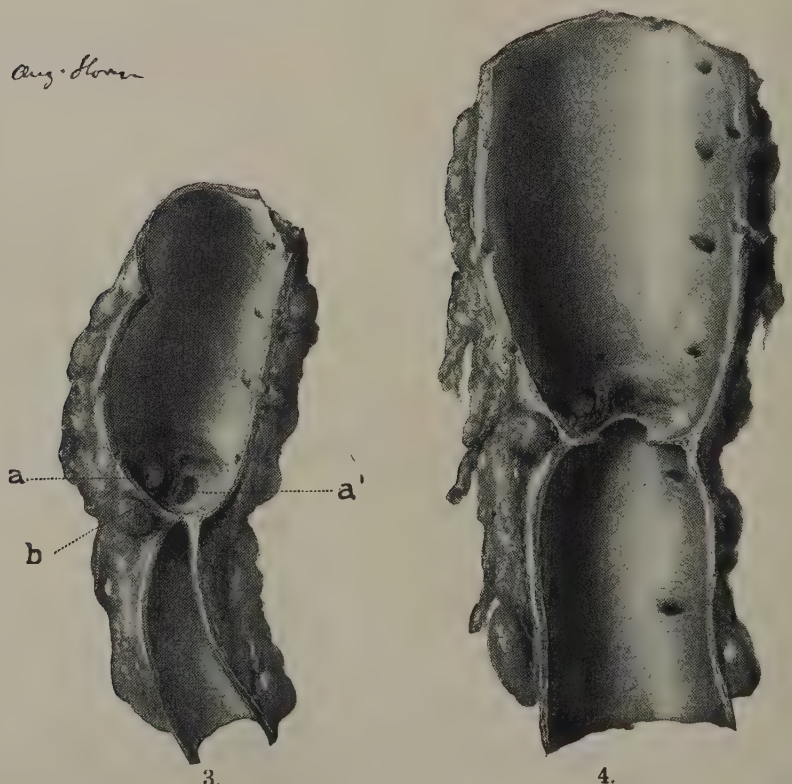
2.

PLATE XXIX



Natural size

1. 2.



3. 4.

PLATE XXX

PARTIAL OCCLUSION OF THE THORACIC AND ABDOMINAL AORTAS BY BANDS OF FRESH AORTA AND OF FASCIA LATA[1]

Ligation of the human abdominal aorta has been made nineteen or twenty times and always with fatal result.

Dubois, Assalini, Bujalsky, Cooper, Keen, and perhaps others, attempted to occlude the abdominal aorta gradually by means of cleverly devised instruments which, carrying snares of silk, metal, or catgut, might be tightened or loosened at will. The instruments traversed the abdominal wall and hence infection was a complication common to all of the methods and defeated the plans of the operators.

In 1904, assisted by Dr. W. F. Sowers, I began a series of experiments on dogs in the hope of finding a safe method of occluding the aorta and curing aortic aneurism. Bands of silver and aluminum curled about the aorta by an instrument constructed for this purpose were rolled tighter by the fingers until the desired degree of occlusion of this vessel was obtained. The abdominal wounds were closed with the expectation that they would have to be reopened one or more times for the purpose of progressively occluding the lumen of the artery. But in the course of our experiments we had opportunities to make trial in the human subject of partially occluding bands on other arteries (innominate, subclavian, carotid, femoral, popliteal) whose blood streams in some instances it seemed unsafe to cut off suddenly and completely, and found that occlusion of an artery, carried to the point of obliterating the pulse, usually sufficed to cure the aneurism, possibly quite as surely as might have been expected of total occlusion. Hence, tentatively, I abandoned the idea of progressive closure of the aorta, determining, instead, to obliterate the lumen of this vessel, in the attempt to cure its aneurism, to an extent which we had found quite safe in the dog.

I have applied an aluminum band to the human aorta four times; twice in one subject and twice with promising results so far as the cure of the aneurism is concerned. But the experimental work on animals had led me

[1] Presented before the American Surgical Association, Washington, D. C., May 7, 1913.

Also presented at the Society of Experimental Biology and Medicine, 52nd. Meeting, N. Y., February 19, 1913.

Tr. Am. Surg. Ass., Phila., 1913, xxxi, 218-222. (Reprinted.)

Also: Ann. Surg., Phila., 1913, lviii, 183-187.

Also: (Abstr.) Proc. Soc. Exper. Biol. & Med., N. Y., 1912-1913, x, 113-116.

to expect that ultimately the metal bands must cut through the artery because in cases observed for seven months or less the wall of the aorta had become atrophied to the thinness of paper and there was no adhesion between the infolded, attenuated surfaces. That my fears were well founded was proved by an experience in Europe, about eighteen months ago. The patient was an aged woman with dilated and badly functioning heart. The large aortic aneurism was well located for the placing of a band which was applied just below the renal vessels. Within a few days the aneurism, which before operation was distinctly visible from the seats of the operating amphitheatre, was barely discernible at the bedside, and at the end of six weeks had disappeared so completely that the patient was discharged apparently cured. But, walking out of the door of the hospital she was seized with a pain and returned to her bed. The following morning she died from haemorrhage. The aorta had ruptured at the site of the band, but the aneurism was found to be nearly cured.

Stimulated by the result in this case to further experimentation, it occurred to me to test the behavior of cuffs and spiral strips of the fresh aorta of one dog when wound about the aorta of another. So on April 29, 1912, I operated upon two dogs, partially occluding the aorta of one of them with a spiral aortic band and of the other with a cuff cut from the same vessel. Strips of aorta were employed rather than of fascia lata, for example, because I hoped that the elastic tissue, in case it did not endure might, at least, serve its purpose for a time sufficient to cure an aneurism.

At the end of two months one of the dogs was killed and I was pleased to find that the cuff which had been used in this experiment was apparently organized and had not stretched to any appreciable extent. Above the cuff the aortic pulse was forcible, but below the constriction it was very feeble, though countable and accompanied by a thrill.

The other dog operated upon at the same time and in the same manner, except that a spiral band of aorta instead of a cuff had been employed, died (cause of death unascertained) about three weeks after the operation. In this instance the aorta had been almost completely occluded by the spiral aortic strip. The welt-like band had not stretched and seemed to be organized. The aorta, on being split longitudinally, was seen to be greatly wrinkled and almost occluded at the site of the band. Sections of the specimens indicated that the elastic coats of the bands as well as of the included artery were intact.[2] During the present winter I have made about twenty-five

[2] These observations were briefly reported a year ago in a footnote to an article entitled "The Effect of Ligation of the Common Iliac Artery on the Circulation and Function of the Lower Extremity," Johns Hopkins Hospital Bulletin, July, 1912, p. 217.

similar experiments with encouraging results. We have learned, however, that whereas the spiral bands seem to be perfectly safe, there is danger in the employment of the cuffs. In two instances of twelve or more experiments, one of the mattress sutures taken to hold the flaps of the cuffs together cut part way through the cuffs and thus, being brought in contact with the aortic wall, wore a minute hole in the vessel through which the animal bled to death. Such an accident can hardly happen with the employment of the spiral strip, for not only is the strain on the stitches very slight when this form of band is used, but even if it were so great that a thread might cut through the spiral at any point, it could hardly be brought to bear upon the aorta in such a way as to wear into its wall.

To each end of the band of fresh tissue a narrow tape is sewed to facilitate the manipulation of the transplant, which is wound twice about the aorta. When one or two stitches have been taken at one end to hold the contiguous edges of the spiral together at this point, the other end of the strip is pulled upon until the aorta is occluded to a little more than the desired amount, and then two additional stitches are taken to maintain the constriction.

Within the past few weeks I have examined the bands of aorta, fascia lata, and chromicized submucosa which had been wound about the aorta last autumn and winter. In two instances in which considerable constriction of the aorta had been made about four months previously, kymographic tracings of the blood pressure in the femoral and carotid arteries were made in the physiological laboratory by Professor Howell and Mr. Cecil. To our surprise there was no diminution in the femoral pressure, and on investigating the band it was found in each instance to have relaxed and to have been partially absorbed.

In dogs operated upon as long as seven months ago there was considerable absorption of the band; and in one instance only a trace of it remained. One spiral band which had been applied so as to make almost total occlusion seven months before seemed microscopically to be well preserved, but it no longer constricted the aorta, the lumen of which was completely restored, and whose underlying wall was apparently normal.

These findings do not discourage me, for if the constriction can be maintained for two months or even one month, it might effect the cure of an aneurism, and if not, a totally occluding ligature might perhaps, after such lapse of time, be applied without great risk, and possibly the aneurism in some cases might then be excised. The desirability of transplanting, when feasible, a segment of vessel must always be borne in mind.

About three weeks ago I received from Dr. Francesco Nassetti a reprint of a paper by him entitled "Avvolgimento di vasi Sanguigni con lembi liberi di aponeurosi," and published April 26, 1912, in the *Atti della R. Academia*

dei Fisiocritici in Siena. Dr. Nassetti's experiments were made in the Istituto di Pathalogia Speciale Chirurgica della R. Università di Siena, which is under the direction of Prof. A. Salomoni. His first experiment (a band of fascia about the carotid artery) antedates mine by fifty-six days, and his article appeared about three months before the publication by me of a brief account of my first experiments with spiral strips of aorta (*Johns Hopkins Hospital Bulletin,* July, 1912, p. 217). Dr. Nassetti has written on the cover of the reprint which he kindly sent me that his article appeared in print April 26, 1912. My first experiment with the bands of fresh aortic wall was made April 29, 1912, three days after the publication of Nassetti's report. Hence the credit for the idea of constricting blood vessels with bands of fresh tissue belongs, I am happy to say, to Italy, the country of the famous surgeon, Luigi Porta, who was, I think, the first to attempt the partial occlusion of an artery. I have the impression that Porta used for this purpose a strip of diachylon plaster.

DER PARTIELLE VERSCHLUSS GROSSER ARTERIEN[1]

Die Unterbindung der Bauchaorta beim Menschen ist zwanzig Mal oder noch öfter ausgeführt worden und zwar immer mit tödlichem Ausgange. Dubois, Assalini, Bujalsky, Cooper, Keen und andere versuchten die Bauchaorta unter Anwendung klug ausgedachter Instrumente schrittweise zu verlegen, indem sie Schlingen von Draht, Seide oder Catgut herumführten und diese, nach Belieben, fester oder loser anlegten. Da aber diese Instrumente aus dem Bauche herausragten, so war die Infektion von hier aus die unvermeidliche Komplikation aller dieser Methoden und sie war es, die die Pläne der Operateure zu nichte machte.

Im Jahre 1904 unternahm ich eine Reihe von Versuchen an Hunden, in der Hoffnung eine ungefährliche Methode, die Aorta zu verlegen und das Aortenaneurysma zu heilen, ausarbeiten zu können. Mit einem eigens zu diesem Zwecke konstruierten Instrumente (s. Platte XXVIII, 2, und Platte XXXI) ringelte ich Silber- und Aluminiumbänder um die Aorta und rollte sie unter den Fingern noch stärker an, bis der gewünschte Grad des Gefässverschlusses erreicht war. Die Bauchwunde wurde geschlossen in der Erwartung, das Abdomen ein oder zweimal wieder zu eröffnen, um das Gefässlumen fortgesetzt weiter zu verengern. Im Verlaufe unserer Experimente hatten wir Gelegenheit, am Menschen den partiellen Bandverschluss zu versuchen und zwar an anderen Arterien (z. B. der A. anonyma, subclavia, carotis, femoralis, poplitea), deren Blutstrom plötzlich und vollständig zu unterbrechen gefährlich erschien.

Wir fanden, dass der Gefässverschluss bis zu dem Momente, wo der Puls verschwindet, manchesmal ausreichte, um das Aneurysma zu heilen, möglicherweise fast so sicher wie man es in denselben Fällen beim Totalverschluss hätte erwarten können. Von hier an änderte ich deshalb den Plan des fortgesetzten Aortenverschlusses. Die Idee einer progressiven Gefässlumenverlegung aufgebend, beschloss ich, die Aorta auf einmal so weit zu verschliessen, wie wir es ohne Gefahr tun könnten.

[1] Auszugsweise vorgetragen am 2. Sitzungstage des XLIII. Kongresses der Deutschen Gesellschaft für Chirurgie, 16. April 1914.

Presented at the 43rd. Kongresses der deutschen Gesellschaft für Chirurgie. Berlin, April 16, 1914.

Archiv. f. klin. Chir., Berl., 1914, cv, 580-599. (Reprinted.)

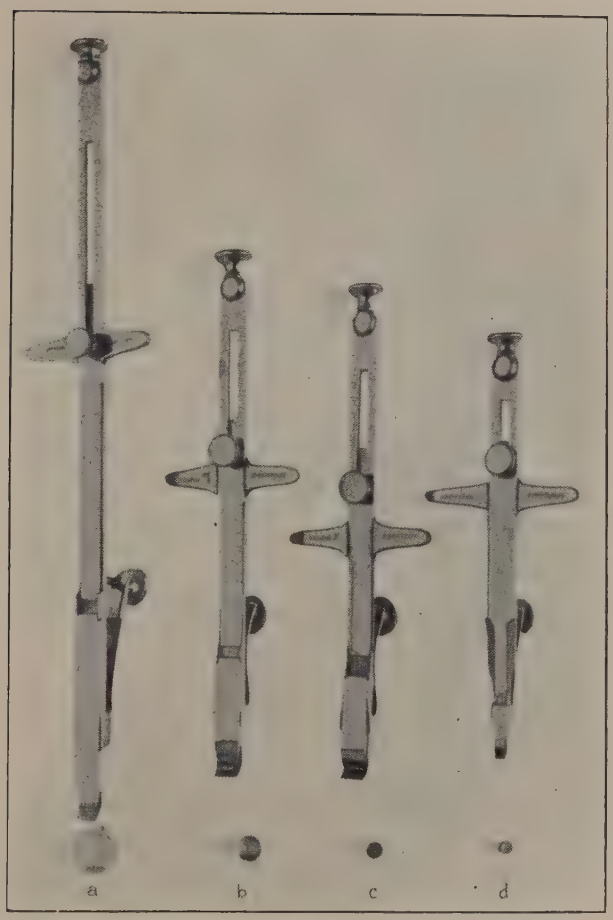
Also: Verhandl. d. deutsch. Gesellsch. f. Chir., Berl., 1914, xliii, 2. Teil, 349-367.

Viermal habe ich bei der Aorta des Menschen eine Aluminiumbandrolle verwendet, zweimal mit aussichtsreichem Erfolge, soweit es allein die Heilung des Aneurysmas betraf.

Die experimentelle Untersuchung an Tieren aber hat mich bewogen abzuwarten, da schliesslich die Metallbandrolle die Arterie durchdringen musste. Denn in Fällen, die ich sieben Monate oder längere Zeit beobachtet hatte, war die Aortenwand bis zu Papierdünne atrophisch geworden (s. Platte XXIX, 1 und 2), und nirgends waren an der gefalteten und verdünnten inneren Oberfläche Adhäsionen vorhanden. Dass meine Befürchtungen wohl begründet waren, ist durch einen Versuch in der Klinik von Prof. Kocher vor drei Jahren bewiesen worden. Die Patientin war eine bejahrte Frau mit dilatiertem und unregelmässig arbeitendem Herzen. Das grosse Aortenaneurysma war sehr geeignet für die Anlegung des Bandes, welches unmittelbar unter den Nierenarterien herumgelegt wurde. Innerhalb weniger Tage war das Aneurysma, das vor der Operation von den Sitzen des amphitheatralischen Operationssaales deutlich sichtbar gewesen war, nur noch am Bett zu erkennen, und nach Ablauf von sechs Wochen war es so vollkommen verschwunden, dass die Patientin, scheinbar fast geheilt, entlassen werden sollte. Allein in dem Momente, wo sie die Schwelle des Krankenhauses überschreiten wollte, wurde sie von heftigem Schmerze gepackt und kehrte zu ihrem Bett zurück. Am nächsten Morgen starb sie an innerer Verblutung. Die Aorta war geborsten an der Stelle, wo das Band lag; das Aneurysma aber wurde um vielleicht drei Viertel verkleinert gefunden.

Durch das Resultat in diesen Fällen zu weiteren Versuchen ermutigt, kam ich auf den Gedanken, Manschetten und Spiralstreifen frischer Hundeaorta auszuprobieren, welche rings um die Aorta eines anderen Hundes gewunden wurden. Nach diesem Prinzip operierte ich am 29. April 1912 zwei Hunde; bei dem einen verschloss ich die Aorta unvollständig durch ein spiraliges Band, bei dem anderen mit einem manschettenartigen Streifen, der aus der Aorta eines dritten Hundes geschnitten war. Streifen aus der Aorta wurden lieber verwendet als z. B. Fascia lata, weil ich hoffte, dass das elastische Gewebe für den Fall, dass es nicht dauernd erhalten bliebe, doch wenigstens für einige Zeit den Zweck erfüllen möchte, lange genug vielleicht, um das Aneurysma zu heilen.

Nach Verlauf von zwei Monaten wurde der eine von den Hunden getötet, und ich war erfreut zu finden, dass die bei diesem Versuche verwendete Aortenmanschette vollständig organisiert zu sein schien und sich nicht nachweisbar ausgedehnt hatte. Oberhalb des Bandes war die Aortenpulsation kräftig, dagegen unterhalb der Umschnürung nur schwach, doch zählbar, und jedesmal von einem Schwirren begleitet.



Das Bandrollinstrument in vier verschiedenen Grössen. Vor jedem liegt ein Metallring, dessen Grösse derjenigen des betreffenden Instruments entspricht. Grösse a findet Verwendung an der Aorta; Grösse b an der Carotis der Iliaca Externa, Femoralis, Poplitea; Grösse c und d bei Tierexperimenten.

Der andere, zu derselben Zeit und nach demselben Prinzip operierte Hund, ausgenommen, dass ein Spiralband von Aortengewebe anstatt einer Manschette desselben angewendet worden war, starb spontan etwa drei Wochen nach der Operation. Bei diesem Tier war die Aorta fast vollständig durch das spiralige Band verschlossen. Das Band hatte nicht nachgegeben und schien organisiert zu sein. Auf dem Längsschnitt war zu erkennen, dass die Aorta stark gefaltet und an der Stelle, wo das Band lag, beinahe verlegt war. Die mikroskopische Untersuchung des Präparates stellte fest, dass die elastischen Fasern sowohl des umgelegten Aortenbandes, wie auch der umschnürten Aorta selber überall beinahe intakt waren.

Während des Winters 1912-1913 habe ich etwa 25 ähnliche Versuche angestellt mit durchaus ermutigenden Resultaten. Folgendes haben wir aber gelernt. Während die Spiralbänder wahrscheinlich vollkommen ungefährlich sind, ist vor der Anwendung von Manschetten zu warnen.

Zweimal bei 12 oder mehr Versuchstieren schnitt eine der Matratzennähte, die zur Fixation der Mannschetten benutzt worden waren, durch die Manschetten hindurch, wurde somit in Kontakt gebracht mit der Aortenwand und rieb ein kleines Loch in die Aorta, durch welches sich das Tier tödlich verblutete. Solch ein Unglücksfall kann kaum passieren, wenn man Spiralstreifen nimmt. Denn meist ist die Spannung an den Nahtstellen sehr unbedeutend bei Verwendung dieser Bandstreifen. Aber, selbst den Fall gesetzt, sie wäre so gross, dass die Fäden die Spirale an einer Stelle durchschnitten, so könnten diese kaum nach dem beschriebenen Modus auf die Aorta gebracht werden und das Gefäss usurieren.

Technik bei der Anlegung der Spirale

Jedes Ende des Bandes von frischem Gewebe wird zur leichteren Handhabung des Transplantates, das zweimal um die Aorta gewickelt wird, mit einem breiten Zwirnsfaden versehen. Wenn zwei Nähte an dem einen Ende gelegt sind, um die anstossenden Ränder der Spirale an einem Punkte mit einander zu fixieren, wird das andere Ende des Streifens angezogen, bis die Aorta um den gewünschten Grad verschlossen ist, dann wird durch zwei weitere Nähte die Umschnürung aufrecht erhalten.

Vor anderthalb Jahren untersuchte ich die Spiralbänder der Aorta, Fascia lata und Chromcatgut, die ich um die Aorta von Hunden gewunden und bestimmte Zeitperioden, zwei bis sieben Monate, liegen gelassen hatte. Bei zwei Hunden, bei denen die vorläufige Umschnürung der Aorta vor 4 Monaten gemacht worden war, wurde mit dem Kymographion die Blutdruckkurve an der Femoralis und der Carotis im Physiologischen Institute von Professor Howell und Dr. Cecil aufgezeichnet. Zu unserer Ueberraschung bestand keine Herabsetzung des Blutdruckes in der Femoralis gegenüber

dem in der Carotis. Die Prüfung der Bänder wurde vorgenommen und es zeigte sich bei beiden Tieren, dass nicht nur die Bänder nachgegeben hatten, sondern mehr oder weniger resorbiert waren. Von einem Bande, das 7 Monate vor Tötung des Hundes umgelegt worden war, blieb nur eine Spur zurück. Ein Spiralband, das zur Erzeugung eines fast vollkommenen Verschlusses 7 Monate vorher umgelegt worden war, erschien makroskopisch gut erhalten zu sein. Aber es hatte die Aorta nicht mehr komprimiert; ihr Lumen war vollkommen wieder hergestellt und die Wand war scheinbar normal.

Diese Befunde indessen sollen uns nicht entmutigen, denn wenn die Umschnürung für sechs Wochen oder zwei Monate erhalten werden kann, so könnte dieses möglicherweise ausreichen, um die Heilung des Aneurysmas herbeizuführen; und wenn nicht, ein totaler Verschluss des Rohres durch die Ligatur kann nach dieser Zeitspanne mit geringerem Risiko ausgeführt werden.

Vor etwa einem Jahre erhielt ich von Dr. Francesco Nasetti einen Separatabzug seiner Arbeit, betitelt: „Avvolgimento di vasi sanguigni con lembi liberi di aponeurosi", die am 26. April 1912 in der Atti della R. Accademia dei Fisiocritici in Siena publiciert ist. Dr. Nasetti's Untersuchungen wurden im Institute der speziellen pathologischen Chirurgie der Universität Siena (Dir. Prof. A. Salomoni) angestellt. Mein erstes Experiment mit Streifen frischer Aortenwand wurde am 29. April 1912, drei Tage nach der Publikation Nassetti's gemacht. Indessen gehört das Anrecht dieser Idee, Blutgefässe mit frischen Gewebsbändern zu umschnüren, Italien, dem Vaterlande des hervorragenden Chirurgen Luigi Porta, der soviel ich weiss, der erste war, der den partiellen Verschluss von Arterien versucht hat.

Da der partielle Verschluss der Aorta bei Anwendung lebenden Gewebes sich nicht länger als nur wenige Wochen erhält, und da ferner die Wandatrophie der Aorta mit ihrer drohenden Gefahr unter dem Metallband unvermeidlich ist, habe ich im vergangenen Winter mit Spiralbändern von Leinen Versuche gemacht. Ich hoffte, dass das Granulationsgewebe möglicherweise in die Maschen des Bandes eindringen und dieses bis zu einem gewissen Grade für einen längeren Zeitraum dem Arterienrohr einverleiben könnte. Mein Wunsch ging dahin, ein Band mit möglichst weiten Oeffnungen anzuwenden, und so wurde mein erster Versuch mit einem Gazestreifen gemacht, der flach auf ein Stück frische Fascia lata aufgenäht wurde. Diese Kombination von Gaze und Fascia lata wurde in spiraligen Touren um die Aorta gewunden und zwar so, dass die Gaze auf die Gefässwand zu liegen kam. Innerhalb zweier Tage hatte einer von den feinen Gazefäden die Aorta durchschnitten und das Tier hatte sich tödlich verblutet. Sodann wurde die allerfeinste Seidenborte versucht. Sobald diese aber durch die

Gewebsflüssigkeit feucht geworden war und dann angezogen wurde, drehte sie sich zu einem feinen Strang zusammen und konnte dann nicht mehr flach um das Gefäss gelegt werden. Bänder dagegen, die in alkoholischer Schellacklösung getränkt und dann getrocknet waren, liessen sich in befriedigender Weise als Spirale verwenden. Wir wandten auch leinene Spiralbänder von grösserer Stärke an, und haben die Absicht, mehrere dieser so behandelter Tiere ein Jahr oder noch länger zu beobachten. Einige von ihnen wurden im Oktober 1913 operiert und sie sind allesamt in gutem Zustande. Drei Hunde, bei denen ich diese stärkeren Spiralbänder angewandt habe, wurden getötet. Es atrophiert nun die Aortenwand unter diesen Bändern genau so, wie unter dem Metallring, und es dürfte von Interesse sein, die genauen Einzelheiten des Prozesses, der hier und da zur Bildung eines bindegewebigen Stranges unter dem Bande führt, auseinanderzusetzen.

Exp. 1.—Die Aorta wurde stark durch eine kräftige Seidenligatur gequetscht und über diese Quetschfurche wurde ein Spiralband gelegt. Die Untersuchung der Aorta nach 2 Monaten ergab, dass die Intima sich im Bereiche der Quetschfurche regeneriert hatte, die anderen Schichten der Gefässe aber nicht.

Exp. 2.—Bei einem anderen Tiere führte ich einen Seidenfaden durch einen Stichkanal in das Lumen der Aorta ein und an einer anderen Stelle wieder heraus. Diese Ligatur, die geknotet wurde, musste auf eine kurze Strecke frei auf der Innenfläche des Gefässrohres verbleiben. Die Blutung, die nach diesem Manöver erfolgte, wurde durch Anwendung des Spiralbandes zum Stehen gebracht. Die Untersuchung nach 2 Monaten ergab, dass der Teil des Seidenfadens, der sich wie eine Bogensehne zwischen einem kleinen Arcus der Aortenwand ausgespannt hatte, durch negebildete und normal aussehende Intima hindurchschimmerte.

Exp. 3.—Ein feiner Seidenfaden, der fest genug angezogen war, um eine ansehnliche Umschnürung der Aorta herbeizuführen, wurde mit einem Spiralbande bedeckt, das noch weiter das Lumen verengerte. Nach ungefähr 6 Wochen konnte man die Ligatur durch normale Intima hindurchschimmern sehen. Die äusseren Gefässschichten unter dem Bande waren verdünnt, und die Ligatur lag lose und frei zwischen dem Spiralbande und der komprimierten Aortenwand.

In keinem unserer Versuche haben wir die geringste Spur von Thrombosenbildung gesehen. In dieser Hinsicht steht unsere Erfahrung in auffallendem Gegensatz zu derjenigen anderer Forscher, welche den Totalverschluss mit Ligatur ausgeführt haben.

Beim Menschen, wie gesagt, hatte ich viermal Gelegenheit, den Effekt des partiellen Aortenverschlusses zu beobachten. In keinem Falle hatten sich beunruhigende Symptome gezeigt, obgleich bei einem Kranken der Aortenverschluss fast so vollkommen gemacht worden war, dass der Femoralpuls sistierte. Diese Resultate stehen in eklatantem Gegensatz zu denjenigen, die nach vollständigem Verschlusse der Aorta erreicht sind.

Nach vollständigem Verschlusse der Bauchaorta bei Hunden kehrt der Puls der Femoralis gewöhnlich nicht in mehreren Wochen zurück und in einigen Fällen konnten wir ihn erst nach sieben Monaten palpatorisch nachweisen. Die Kollateralbahnen nehmen ihren Weg durch die in so schöner Weise von Luigi Porta dargestellten Vasa vasorum und durch die Mammaria interna und die epigastrischen Gefässe, auf die auch besonders durch Kast mit Nachdruck hingewiesen ist. Wir haben wiederholt die grosse Zunahme der Gefässversorgung in der Bauchwand nach komplettem Verschlusse der Aorta beobachten können.

Es ist erstaunlich, dass sogar nach langen Zeiträumen der Blutdruck oberhalb und unterhalb des Metallbandes so sehr verschieden ist.

Beispiel. Hund Nr. 96. Operation am 22. 5. 1906. Die Lungen wurden nach Tracheotomie in gleichmässiger Athmung durch Gebläse erhalten. Ein Aluminiumband von 6 mm Breite und einer Dicke von Nr. 3 der amerikanischen Metallskala wurden um die Aorta thoracica genau oberhalb der stärksten Wölbung des Zwerchfelles gelegt.

19 Tage nach der Operation war der Hund vollkommen munter, wenngleich sehr schwach und steif auf den Hinterbeinen. Am 20. Tage trat plötzlich im Befinden des Tieres ein Wechsel ein. Der Hund war sehr matt, athmete ganz oberflächlich und die Hinterbeine waren vollständig gelähmt. In zwei oder drei Tagen war ein geringer Grad von Bewegung der Hinterbeine zurückgekehrt.

21. 12. Sieben Monate nach der Operation war der Hund vollkommen munter, wenngleich noch sehr schwach auf den Hinterbeinen. Der Femoralpuls konnte mit Mühe gefühlt, aber nicht mit genügender Sicherheit gezählt werden. Der Thorax wurde unter positivem Druck geöffnet und das Band der Aorta thoracica untersucht. Es war deutlich zu sehen, indem es breit durch die normal aussehende Pleura hindurchschimmerte.

Die Blutdruckuntersuchungen, die von Herrn Dr. Percy Dawson, Associate Professor für Physiologie an der Johns Hopkins Universität ausgeführt wurden, führten zu folgendem Resultate:

	Höchster Druck	Mittlerer Druck	Geringster Druck	Puls-Druck
Femoralis	116	93	88	28
Carotis	160	113	83	77

Bei Kontrollhunden wurden durchschnittlich folgende Werte gefunden:

	Höchster Druck	Mittlerer Druck	Geringster Druck	Puls-Druck
Femoralis	188	120	95	93
Carotis	162	122	103	49

„Auch Druckkurven wurden beim Hunde Nr. 96 aufgezeichnet und zeigten ein vollkommenes Fehlen der dikrotischen Welle beim Femoralis-

puls, während beim Kontrolltier die dikrotische Welle in der Femoralis viel markanter, als in der Carotis ist, so dass die Hyperdikrotie klarer in der ersteren, als in der letzteren aufzuzeichnen ist."

„ Beträchliche Veränderungen betreffs der Schnelligkeit der Pulswellen bieten sich bei den verschiedenen Hunden dar. Nichtsdestoweniger lässt sich mit Sicherheit behaupten, dass die Schnelligkeit von nur 556 cm in der Sekunde, die bei diesem Tiere gefunden wurde, ihren niedrigen Wert der Aorten-Umschnürung verdankt."

Es erschien uns bemerkenswert, dass nach einer so langen Zeit (annähernd nach 7 Monaten) ein solcher Unterschied im Pulsdruck oberhalb und unterhalb der partiellen Umschnürung vorhanden war. Das Herz pumpte durch das Band einen schmalen Strom hindurch von einer Dicke, wie ihn etwa die Arteria radialis des Menschen zu führen pflegt. Die Pulsdruckdifferenz oberhalb und unterhalb der Bandes betrug 49 mm, während der geringste Differenz-Druck 5 mm Quecksilber ergab.

Es wird damit verständlich, dass der partielle Bandverschluss, der die Pulswelle abschliesst, aber noch einen dünnen Blutstrom unter dem Bande hindurchlässt, ausreicht, in einem bestimmten Prozentsatz von Fällen, das Aneurysma zu heilen. Gewöhnlich besteht eine erhebliche Differenz in Form und Dicke der Aorta oberhalb und unterhalb des Bandes. Die Arterienwand über dem Bande mag mehr als zweimal so dick sein als unter demselben, und ist gewöhnlich dilatiert (s. Platte XXIX, 4).

Den partiellen Gefässverschluss mit dem Metallring habe ich beim Menschen bei allen grossen Arterien angewandt, so: einmal bei der Aorta thoracica; dreimal bei der Aorta abdominalis; einmal bei der Arteria anonyma; zweimal bei der A. subclavia; einmal bei der A. iliaca communis; zweimal bei der A. iliaca externa; zweimal bei der A. femoralis; einmal bei der A. poplitea, und verschiedene Male bei der A. carotis.

Ein Band wurde mit offensichtlichem Nutzen für das Herz bei einer stark dilatierten Vena iliofemoralis oberhalb einer arteriovenösen Kommunikation angewandt. Diese hatte ich sorgfältig freigelegt, in der Hoffnung, die Kommunikationsöffnung derselben ohne Obliteration von Vene oder Arterie verschliessen zu können. Ein anderes Mal, während ich dabei war, ein Band um die A. ileofemoralis unmittelbar über einem Aneurysma dieser Arterie anzulegen, wurde der Kranke plötzlich tief cyanotisch und in wenigen Minuten hörte er auf zu athmen. In der Annahme, dass ein verborgenes Aneurysma des Aortenbogens auf die Trachea drücken könnte, wurde ein Gummirohr in diese eingeführt. Dieses verschaffte dem Kranken an der Trachealstenose genügende Erleichterung, so dass ich in die Lage versetzt war, mein Vorhaben zu Ende zu führen. 24 Stunden später starb der Kranke plötzlich in Folge von Ruptur eines kleinen Aortenaneurysmas,

welches der Grund der Trachealstenose gewesen war. Dieser Fall erinnert mich an eine fast identische Krankenbeobachtung, die mehrere Jahre zurückliegt. Es handelte sich um einen Notfall. Bei dem Kranken, der bewusstlos dem Hospital zugeführt wurde, versuchte ich 3 Stunden lang das Aortenaneurysma auszupräparieren. Dieses drückte so heftig auf die Bifurkation der Trachea, dass ein steifer Gummikatheter durch die Trachealstenose hindurchgeführt, in solchem Grade plattgedrückt wurde, dass der Patient kein anderes Anästheticum, als seine eigene Kohlensäure, bei der Operation nötig hatte. Bei der Autopsie, die auf dem Operationstisch ausgeführt wurde, fand sich, dass die Ausschaltung des Aneurysma sacciforme und die Vernähung der Kommunikationsöffnung denkbar gewesen wäre, hätte die Patientin eine oder zwei Stunden länger gelebt.

Bei meinen operativen Versuchen am Aortenbogen des Menschen und des Hundes habe ich den Eindruck gehabt, dass nach chirurgischen Eingriffen in dieser Gegend der Shock ein ungewöhnlich grosser ist und es wird von Interesse sein, auszuprobieren, ob der Shock bei weitgehendem Gebrauche von Lokalanästhesie des Mediastinums sich wesentlich vermindern lässt. Ich möchte hier in Parenthese bemerken, dass ich nicht überzeugt bin, dass bei gewöhnlichen Operationen die Vorteile einer kombinierten örtlichen und allgemeinen Betäubung bedeutend grösser sind als ihre Nachteile. Oder wenigstens nicht so viel grösser, dass die häufige bezw. regelmässige Anwendung der kombinierten Methode indiciert wäre. Die lokale Infiltration mit dem Anästheticum übt manchmal einen ungünstigen Einfluss auf den Heilungsprozess aus, und die Nachwirkungen sogar einer geringen Novocainmenge sind für zartbesaitete Patienten sehr unangenehm und peinlich, fernerhin kommt dazu, dass bei Anwendung der kombinierten Methode die toxische Wirkung des lokal applicierten Anästheticums zu derjenigen der Allgemein-Narkose hinzutritt.

Der partielle Bandverschluss in seiner Anwendung bei Aneurysmen der A. carotis communis hat ganz besonders interessante Resultate gezeitigt. In vier Fällen habe ich ihn in der erfolgreichsten Weise bei diesem Gefässe, zur Beseitigung der Erscheinungen von Seiten der Augen und Ohren, die in evidenter Weise durch die Dilatation des Carotissackes bedingt waren, ausgeführt.

Die Gefahr des plötzlichen kompletten Verschlusses der A. carotis ist so gross, dass man es sich doch überlegen sollte, dieses Gefäss allein zur Beseitigung der Geräusche und des Sausens im Ohr sowie der Beschwerden im Auge und der geringfügigen Sehstörung zu unterbinden. Matas, Professor an der Tulane Universität in New Orleans, der von Anfang an meinem Unternehmen seine tatkräftige Förderung und Unterstützung gewährt hat, hatte Gelegenheit, im Jahre 1907 oder 1908 ein Metallband, das nach seinen

eigenen Angaben gearbeitet war, an der A. carotis communis in Anwendung bringen zu können. Er konstatierte nach Entfernung des Bandes eine vollständige und schnelle Wiederherstellung der ernsten Erscheinungen von Seiten des Gehirns, welche die Folge des Arterienverschlusses gewesen waren. Der partielle Verschluss der Carotis hat unter meinen Fällen nur zweimal unbedeutende und schnell vorübergehende cerebrale Symptome hervorgerufen. In keinem einzigen Falle brauchte ich das Metallband wieder zu entfernen.

Die Aufmerksamkeit dieses Kongresses ist zweimal in Anspruch genommen worden anlässlich der Erörterung des temporären Verschlusses der Arterien, und zwar von Prof. Jordan 1907 und von Dr. Doberauer 1908. Keinem der beiden Autoren war meine frühere Arbeit über diesen Gegenstand bekannt.

Der partielle Bandverschluss hat bestimmte Vorteile vor der temporären Ligatur von Jordan und Doberauer:

1. Das Band braucht nicht wieder entfernt zu werden.

2. Will man das Band wieder entfernen, so sollte man es an seinem Platze einige Monate liegen lassen, bis Kollateralbahnen entstanden sind.

Beiläufig gesagt, zu dem Vorschlage des Herrn Prof. Jordan, eine temporäre Ligatur bei einer verletzten Arterie proximal von der Wundnaht anzulegen, möchte ich bemerken, dass ich wiederholt bei Tieren die in die Aorta gesetzten Wunden dadurch geschlossen habe, dass ich ganz einfach ein nicht komprimierendes Metallband rings über die Wunden herumlegte. Dieses Verfahren dürfte sich für den Verschluss gewisser pathologischer Perforationen der Aorta eignen. Ich habe einen Fall von Berstung eines Aneurysmas der Aorta thoracica gesehen, welcher möglicherweise nach diesem Verfahren erfolgreich hätte behandelt werden können. Durch einen Spalt von der Grösse eines Wurmloches in der Wand der Aorta thoracica hatte das Blut seinen Weg zu den Aa. iliacae communes genommen. Der Kranke lag 4 Tage lang in schwerer Agonie, die dem plötzlichen Einsetzen der ersten Symptome gefolgt war. Es ist für den speziellen Fall von Wichtigkeit hervorzuheben, dass der Dickdarm vom Coecum bis zu der Flexura lienalis so enorm gedehnt war, dass eine tangentiale Colostomie hatte gemacht werden müssen. Kürzlich, als Consiliarius zu einem Knaben gerufen, der an einer enormen Dehnung der Därme im Anschluss an eine Nierenexstirpation litt, glaubte ich, in Erinnerung an diesen soeben citierten Fall, an die Möglichkeit einer inneren Blutung. Die Autopsie deckte ein ausgedehntes extraperitoneales Hämatom auf. Ich erwähne diese Fälle absichtlich, in der Hoffnung, dass vielleicht das eine oder andere Mitglied dieser Gesellschaft in der Lage ist, mir eine Erklärung für diese Form des Ileus geben zu können.

Von den verschiedenen interessanten Fällen des partiellen Verschlusses einer Arterie mittels der Metallbandrolle, die wir gehabt haben, berichte ich den folgenden als Beispiel.

Exstirpation eines iliofemoralen Aneurysmas drei Wochen nach der präliminaren, teilweisen Verschliessung der A. iliaca externa

Walter C., 40jähriger Neger, wurde am 10. 4. 1913 ins Johns Hopkins Hospital aufgenommen. Sieben Monate vor seiner Aufnahme konstatierte der Kranke einen dumpfen Schmerz, wenn er sich bückte und fand eine kleine pulsierende Beule in der linken Leistenbeuge, welche an Grösse stetig zugenommen hatte. Vor 5 Monaten begann das Bein anzuschwellen.

Status: Grosser, muskulöser, kräftiger Neger. Wassermann schwach positiv. Thorax: ohne Befund, mit Ausnahme eines systolischen Geräusches im unteren Teile der linken Unterskapulargegend. Oberflächliche Blutgefässe sklerotisch. Blutdruck 130.

Abdomen aufgetrieben, die Hautvenen über der linken Seite des Leibes geschlängelt, und es besteht ein Oedem der Haut, das bis zur zwölften Rippe verläuft. Ueber der Aorta, die ungewöhnlich breit erscheint, hört man ein deutliches Geräusch. Das linke Bein ist enorm angeschwollen von der Leistengegend bis zur Zehe, und so derb infiltriert, dass ein starker Druck kaum die Andeutung einer Delle hinterlässt. Der ganze Schenkel zittert mit jeder Pulsation, und die Haut der gesammten Extremität ist livid-schwarz verfärbt. In der Gegend der Schenkelbeuge befindet sich eine mächtige pulsierende Geschwulst, die sich von der Nähe der Schambein-Symphyse bis zur Spina iliaca anterior superior ossis ilei erstreckt und die von einer Linie, die durch die beiden vorderen Spinae gezogen ist, nach abwärts bis 10 cm unter das Poupartsche Band reicht. Die genaue Begrenzung des Aneurysmas konnte nicht ausgeführt werden wegen der grossen Schwellung der Weichteile rings um dasselbe; die Angaben betreffs der Grösse sind daher nur schätzungsweise gegeben. Ueber der Geschwulst fühlt die aufgelegte Hand ein Schwirren, und ein Geräusch kann man von der abdominalen Aorta an, nach abwärts bis zu einem Punkte 15 cm unter dem Poupart'schen Bande auskultatorisch nachweisen.

Maasse der beiden Extremitäten

	Rechts	Links
1. In der Linie, die durch die Glutäalfalte geht	48.5 cm	63 cm.
2. Ueber dem Knie quer über der Patella	33.5 "	45 "
3. Ueber der Wade, 15 cm unter dem Kniegelenkspalt	31.5 "	40.5 "
4. Ueber dem Knöchel, 2 cm oberhalb des Malleolus int.	20 "	26.5 "

In der Annahme, dass die Gefahr der Gangrän in diesem Falle ungewöhnlich gross sein würde, entweder bei der Ligatur der A. iliaca externa, bei der Exstirpation des Aneurysmasackes, bei der von Matas angegebenen Endoaneurysmorrhaphie, als auch überhaupt bei jeder Methode, welche das

Aneurysma sofort zur Heilung bringen will, beschloss ich die präliminare partielle Verschliessung der A. iliaca externa auszuführen.

21. 5. 1913. I. Operation. Partielle Verschliessung der linken A. iliaca externa mit Aluminiumband. Die Arterie wurde leicht gefunden. Sie war abnorm gross, lag sehr tief und verlief von hinten nach vorn, anstatt von oben nach unten. Das Gefäss wurde mit zwei langen stumpfen Dissektoren freigemacht, aus seinem Bett herausgehoben mit zwei Haltefäden, zwischen denen das Aluminiumband um dasselbe geringelt wurde. Mit Daumen und Zeigefinger wurde das Band noch fester gerollt, bis ein Schwirren in der Arterie unter demselben deutlich gefühlt werden konnte. Das Band wurde weiter gerollt, so fest, bis auch das Schwirren in der Arterie und die Pulsation im Aneurysma verschwunden war. Ein ganz schwacher, kaum fühlbarer Puls konnte noch gerade in der A. iliaca externa zwischen Band und Aneurysma palpatorisch nachgewiesen werden. Auf diese Weise war das Gefäss, genau dem gewünschten Grade entsprechend, verlegt worden. Der Fuss wurde sofort ganz kalt.

Nach Verschluss der Wunde konnte ein schwaches Geräusch, jetzt beschränkt auf einen Raum nicht über 4 cm im Quadrat, direkt unter dem Poupartschen Bande gehört werden. Doch war dort keine sichere Pulsation im Aneurysma vorhanden.

22. 5. 24 Stunden nach Operation. Circulation im Fuss gebessert. Patient kann die Zehen und das Fussgelenk frei bewegen. Er hat einige Schmerzen im Bein gehabt. Während der Nacht waren die Zehen taub und gegen Berührung unempfindlich. Hätten wir die Arterie vollkommen verschlossen, so wäre wahrscheinlich Gangrän eingetreten.

23. 5. Die Schwellung des Gliedes ist vermindert. Das Schwirren erstreckt sich höher oberhalb des Aneurysmas und entlang dem Verlaufe der A. iliaca externa, als vor der Operation. Höchstwahrscheinlich ist das Band die Ursache dieser Erscheinung.

Ich möchte an dieser Stelle bemerken, dass das erwähnte Schwirren bei unseren Tierversuchen, wie bei den operierten Kranken ein wichtiger Massstab gewesen ist, da es ziemlich genau den Grad der erreichten Umschnürung anzuzeigen pflegte. In den Protokollen unserer Versuchstiere zum Beispiel lesen wir „Die Arterie ist bis zu dem Eintritt des Schwirrens verlegt worden“, oder „Das Einsetzen des Schwirrens erfolgte, aber der Puls ist noch wahrnehmbar“, oder „Schwirren und Puls sind verschwunden, aber das Gefässlumen ist nicht vollkommen verschlossen“.

25. 5. Patient hat keine Schmerzen mehr. Sensibilität und Temperatursinn des Gliedes sind normal. Ein vorübergehend stark erweiterter Nebenast der Vena saphena magna ist noch weiter sichtbar. Es scheint das Aneurysma zu pulsieren.

6. 6. Die Schwellung des ganzen Gliedes hat seit der Operation stetig abgenommen. Es besteht eine ganz geringe, aber sichere Pulsation im Aneurysma.

7. 6. II. Operation. Entfernung des Aneurysmas. Nach Desinfektion der Haut mit Alkohol und Jodtinktur, wurde das Operationsfeld einschliesslich von Scrotum, Penis, Abdomen, Glutäalgegend, Vorderfläche und Seiten des Gliedes mit einer Schicht von feiner Leinewand, die in Celloidin

getränkt war, bedeckt. Ein langer senkrechter Schnitt wurde durch das trockene Celloidin und die Leinewand über der Konvexität des Aneurysmas an der höchsten Stelle gelegt. Ehe ich mich daran machte die Iliaca communis temporär zu verschliessen, versuchte ich den Sack des Aneurysmas möglichst weit auszuschälen. Ich tat dies: 1. in der Hoffnung, die Operation nicht unnötigerweise durch Auspräparieren der A. iliaca communis zu komplicieren, 2. weil ich den Wunsch hatte, das Verhalten der Kollateralbahnen der A. und V. femoralis kennen zu lernen.

Das Gewebe oberhalb und unterhalb des Aneurysmas erschien abnorm blutreich. Zwei grosse, flache und scheinbar obliterierte Venen lagen an der Innenseite des Sackes. Die A. epigastrica und die A. iliaca externa wurden durchtrennt und unterbunden. Nachdem die Ausschälung des Sackes am oberen Pol und an den Seiten blutlos ausgeführt wurde, schritt ich zur temporären Kompression der A. iliaca communis. Dieses Gefäss wurde freigelegt, indem der Schnitt nach oben über dem linken M. rectus im Verlaufe der alten Operationsnarbe von der I. Sitzung geführt war. Ein dicker Faden wurde zweimal rings um die A. iliaca communis gelegt und gedreht bis die Arterie verschlossen war. Der Grad der Drehung wurde mittelst einer Klemme erhalten.

Ich fand das Aneurysma am unteren Pol des Sackes in einen breiten Trichter endigend, von dessen innerer und hinterer Wand eine grosse Arterie, vermutlich die A. profunda femoris, abging. Unmittelbar unter dieser trichterartigen Erweiterung wurde die A. femoralis zwischen zwei Ligaturen durchtrennt und der Sack von unten nach oben freigemacht. Eine obliterierte Vene, wahrscheinlich die Femoralis, wurde quer durchschnitten und mit dem Sack entfernt. Die vergrösserte A. iliaca externa ging ohne Veränderung ihrer Gestalt unvermittelt in den Aneurysmasack über und zwar an der hinteren Wand des oberen Poles. Das Aneurysma wurde sodann der Länge nach von einem Ende zum andern gespalten und das Blut und die Fibrinmassen schnell ausgeräumt. Die Wand war vollständig trocken, nicht ein einziger Blutpunkt war sichtbar. Es zeigte sich, dass der Sack tief in das Becken hineinreichte. Er hatte wahrscheinlich die A. und V. iliaca interna und ihre Aeste komprimiert. Die weitere Isolierung war sehr einfach und wurde schnell ausgeführt; nicht ein einziges Gefäss brauchte unterbunden zu werden. Nur ganz zum Schluss durchtrennte der letzte Messerschnitt das proximale Ende der peripher obliterierten Vena iliaca externa. Die ganze Operation wurde vollständig unblutig ausgeführt.

Schluss der 45 cm langen Operationswunde. Einlegung einer kleinen Guttaperchacigarette. Verband mit Silberfolie. Nach Beendigung der Operation war der linke Fuss und das linke Bein nach oben bis zum Knie deutlich kälter, als auf der rechten Seite. Ein Unterschied in der Temperaturempfindung beider Beine wurde bis zum 5. Tage beobachtet.

Als der Kranke aus der Narkose erwachte, konnte er die Zehen und das Fussgelenk frei bewegen. Er konstatierte ein taubes Gefühl in seinem Fuss, konnte aber genau Nadelstiche an jedem Punkte lokalisieren, mit Ausnahme am inneren Rande des grossen Zehennagels, und konnte vorzüglich Heiss und Kalt unterscheiden.

11. 6. Erster Verbandwechsel. Wunde per primam völlig geheilt mit Ausnahme der Drainageöffnung. Patient hat sich ausserordentlich wohl

gefühlt und kein Morphium seit der Operation erhalten. Das ganze, stark geschwollene Bein ist sehr viel dünner geworden.

16. 6. (Neun Tage nach der Operation.) Patient ist seit einigen Tagen herumgegangen. Es zeigt sich, dass sein Bein vollkommen wohlauf ist und schnell an Kraft gewinnt. Das ganze Glied ist weich und fast normal. Die anderweitige Schwellung ist in gleicher Weise verschwunden.

November 1913. Der Kranke schreibt voll Enthusiasmus über sein Befinden. Er berichtet, dass er niemals Anzeichen von Oedem oder Schwäche oder Gefühlverlust in seinem linken Bein bemerke. Er sei imstande, seine harte Tagesarbeit ohne ungewöhnliche Ermüdung auszuführen.

Ich habe diesen Fall deshalb so ausführlich wiedergegeben, weil er in überzeugender Weise zu beweisen scheint, dass die Behandlung mit dem Metallband nicht ohne Vorteil war.

Zusammenfassung

1. Gewisse Aneurysmen können durch unvollständigen Verschluss der Arterie geheilt werden.

2. Die menschliche Aorta kann ohne Gefahr bis zu einem Volumen verschlossen werden, welches genügt, um den Femoralpuls zu unterdrücken.

3. Sollte eine Heilung des Aortenaneurysmas auf dem Wege des primären teilweisen Verschlusses nicht zustande kommen, so kann man die Arterie in der Folgezeit noch weiter komprimieren oder vielleicht unterbinden, je nachdem das Herz durch die Erleichterung, welche ihm der gut ausgebildete Kollateralkreislauf gewährt, auf den vollständigeren resp. totalen Verschluss vorbereitet ist.

4. An der normalen Aorta kann man einen um sie gerollten Metallstreifen mehrere Monate, möglicherweise sogar ein Jahr lang, ohne die Gefahr des Durchbruches liegen lassen, so lange wenigstens als es die Sicherstellung der Circulation auf dem Wege der Anastomosen erfordert. An der erkrankten Aorta, insbesondere wenn die Metallbandrolle an einer trichterförmigen Erweiterung des Gefässes, wie im Falle Prof. Kocher's, angelegt wird, kann die Arterienwand schon in der kurzen Zeit von sechs Wochen usurieren.

5. Der Grad, bis zu welchem die Aorta ohne Schaden bei Herzschwäche komprimiert werden darf, kann natürlich nicht bestimmt festgesetzt werden.

6. Auf Grund meiner Erfahrungen glaube ich, dass eine Metallbandrolle ohne die Gefahr einer Hämorrhagie dauernd an einer Arterie mit Ausnahme der Aorta liegen bleiben kann. Es ist wahrscheinlich, dass in den Fällen von fast vollständigem Arterienverschluss (mit Ausnahme der Aorta) häufig, wenn nicht sogar gewöhnlich, die Bildung eines fibrösen Stranges unter der Metallbandrolle eintritt. Diese Umwandlung der Arterienwände in einen cylindrischen Strang habe ich 4mal bei Versuchen an der Aorta des

Hundes beobachtet. In jedem dieser Versuche war die Aorta fast vollständig durch die Metallbandrolle verschlossen worden.

7. Bei allen Arterien, ausser vielleicht der Aorta, kann die Metallbandrolle so fest umgelegt werden, dass der Puls (nicht aber der Blutstrom) aufgehoben wird, falls nicht der Zustand des Herzens einen so festen Verschluss contraindiciert. Die Gefahr der Gangrän oder Funktionsstörung ist gering, vorausgesetzt, dass nicht die ganze Blutströmung unterbrochen wird.

8. In einigen Fällen von Aortenaneurysma dürfte es möglicherweise ratsamer sein für die Umschnürung anstatt des Metalls die Fascia lata, resp. Aortenwand, zu verwenden; der Grad der Kompression mit der Fascia kann nicht so genau bestimmt, auch nicht aufrecht erhalten werden wie mit dem Metall. Ueberdies ist für die Anwendung von Spiralen aus lebendem Gewebe sehr viel, dagegen für die Anwendung der Metallbandrolle nur sehr wenig Uebung erforderlich.

9. Da die Arterienwand weder von dem partiell noch total verschliessenden Band verletzt wird, so kann man in jedem Augenblicke das Band entfernen, resp. loser oder fester anlegen.

AS TO THE CAUSE OF THE DILATATION OF THE SUBCLAVIAN ARTERY IN CERTAIN CASES OF CERVICAL RIB— EXPERIMENTAL STUDY[1]

In twenty-four or more instances a circumscribed dilatation of the subclavian artery has been observed in cases of cervical rib. The dilatation in these cases is distal to the site of pressure made by the rib.

As to the cause of these aneurisms there has been considerable conjecture, usually prefaced by the comment that their occurrence would be comprehensible if they presented on the proximal instead of on the distal side of the compression.

Weakening of the wall of the artery from erosion or trauma, variable or intermittent pulse pressure, and vasomotor disturbances in nutrition are the suggestions which have been offered to explain the phenomenon.

For several years my experiments in arterial compression have had more or less in view the determination of the cause of this dilatation. For the past year they have been continued by Dr. Mont Reid and myself almost exclusively with the object of shedding light on this problem. In 1906 we (Dr. Richardson, Dr. Dawson and myself) made the observation[2] that after partial occlusion of the thoracic aorta the maximum pressure may be permanently lowered as much as 46 mm. Hg, and the minimum pressure actually increased distal to the constricting band of metal.

The dilatation of the artery observed in arterio-venous fistula might, it seemed to me, have a bearing on the interpretation of the aneurisms in cases of cervical rib. Might not both phenomena, I asked myself, be due to degenerative changes in the arterial wall consequent upon lowered pressure—in the case of the cervical-rib-aneurisms, upon lowering of the pulse pressure.

Now, inasmuch as dilatation of the subclavian artery has relatively so seldom been observed with cervical rib (perhaps 24 times in about 400

[1] By Halsted, W. S., and Reid M.

Presented before the Society for Experimental Biology and Medicine 69th Meeting, Cornell University Medical College, N. Y., October 20, 1915.

(Abstr.) Proc. Soc. Exper. Biol. & Med., N. Y., 1915, xiii, 1-3. (Reprinted.)

[2] Dog 96. Partial Occlusion of Thoracic Aorta

Operation, 22/5/1906. Sacrificed 7 months later

	Maximum pressure	Mean pressure	Minimum pressure	Pulse pressure
Femoral	116	93	88	28
Carotid	160	113	83	77
				435

cases) it seemed to me that if it were due merely to the lowered pulse pressure then only a very definite absolute or relative amount of reduction of the systolic pressure would suffice to produce it.

In June, 1914, I observed, in a dog, for the first time an unquestionable dilatation of the three arteries below the constricting band which had been placed just above the aortic trifurcation. The constriction exercised by the band was sufficient to greatly lessen, if not, indeed, to obliterate the palpable thrill produced by the constriction, but not enough to shut off the palpable pulse. With this observation as fresh incentive, Dr. Reid and I have continued the experiments for the past year and a half with encouraging results: in only one additional instance, however, was there a very striking dilatation. In this, as in the one of the preceding year, the occlusion of the aorta by the band was almost total.

If the occlusion must be so nearly complete in order to effect a pronounced dilatation it will assist to explain not only the difficulty we have had in producing it in dogs, but also the fact that it has been observed relatively so seldom in the human subject from compression of the subclavian artery by a cervical rib. For when in dogs the aortic pulse is occluded beyond the stage of palpable thrill the lumen is in danger of becoming obliterated—as by the formation of a cylindrical fibrous cord beneath the band—and thus cancel the experiment; and in the cervical rib cases we may assume, argumentatively, that the subclavian artery, compressed to the stage sufficient to produce an aneurism, is likely to become totally occluded in the presumably considerable time required for the manifestation of the dilatation. Thus, in dogs, a number of months must apparently elapse after the application of the band before a dilatation in striking degree can occur. In the two cases, observed just one year apart, 5 months and 20 days, and 6 months and 19 days, respectively, had elapsed. In the second of these, however, a dilatation of less than 1 mm. was found at the expiration of 2 months.

AN EXPERIMENTAL STUDY OF CIRCUMSCRIBED DILATION OF AN ARTERY IMMEDIATELY DISTAL TO A PARTIALLY OCCLUDING BAND, AND ITS BEARING ON THE DILATION OF THE SUBCLAVIAN ARTERY OBSERVED IN CERTAIN CASES OF CERVICAL RIB [1]

No one, since Deitmar,[2] has attempted to collate the cases of dilation of the subclavian artery associated with cervical rib. Deitmar cites five cases (Adams, Coote, Poland, Baum, and von Heinecke), including one (von Heinecke's) which I have tabulated as doubtful. Streissler's review [3] is perhaps the fullest in the literature on the subject of cervical rib. Although it appeared less than 3 years ago no addition is made by this author to Deitmar's list.

From a careful study, in the original, of the reports of 716 cases of cervical rib I find that aneurysm or dilation of the subclavian artery was noted in 27 or more of them, including six (Mayo, Murphy, Russel, von Heinecke, Galloway, and Seymour) in which the surgeon believed that the vessel was abnormally large, and two (Karg and Halsted) in which the aneurysm appeared promptly after removal of the supernumerary rib. There may be numerous other instances of dilation of the subclavian associated with cervical rib—cases in which the amount of arterial expansion could not be determined in the lack of a standard of comparison.

The Dilation of the Subclavian Artery Is Distal to the Line of Constriction Made by the Rib and the Scalenus Anticus Muscle

As to the cause of these aneurisms there is much conjecture. The comment has frequently been made that their occurrence would be comprehensible if they appeared on the proximal instead of the peripheral side of the compression. No one has remarked that dilation central to the site of pressure might be even more difficult to comprehend.

[1] It is possible in the limits of the permissible space to present the results of the work of Dr. Reid and myself in merest outline. A full account will probably appear next year in the Reports of The Johns Hopkins Hospital.

Presented before the American Surgical Association, Washington, D. C., May 9-11, 1916.

Received for publication June 27, 1916.

J. Exper. M., Balt., 1916, xxiv, 271-286. (Reprinted.)

Also: Tr. Am. Surg. Ass., Phila., 1916, xxxiv, 273-288.

[2] Deitmar, J., Inaug. Diss., Erlangen, 1907.

[3] Streissler, E., *Ergebn. Chir. u. Orthop.*, 1913, v, 280.

The suggestions which have been offered in the effort to explain the phenomenon are as follows: (1) weakening of the wall of the artery from erosion or other trauma; (2) variable or intermittent pulse pressure; (3) vasomotor and vasa vasorum disturbances.

In 1906 Dr. E. H. Richardson and I made the observation that after partial occlusion of the thoracic aorta the maximum pressure may be permanently lowered and the minimum pressure actually increased distal to the constricting band of metal. This discovery was verified by Dr. Dawson on one of my dogs (No. 96).

Dog 96. Partial Occlusion of the Thoracic Aorta

Operation, May 22, 1906. Killed 7 months later

	Maximum pressure	Mean pressure	Minimum pressure	Pulse pressure
Femoral	116	93	88	28
Carotid	160	113	83	77

The dilation of the artery observed in arterio-venous fistula might, I thought, have a bearing on the interpretation of the aneurisms in cases of cervical rib. "May not both phenomena," I asked myself, "be due to degenerative changes in the arterial wall consequent upon lowered pressure?"

Inasmuch as dilation of the subclavian artery has, relatively to the number of cases of cervical rib, so seldom been observed, it seemed that if it were due merely to the lowered pulse pressure, then only a very definite absolute or relative amount of reduction of the systolic pressure would suffice to produce it. It was realized, also, that even if the amount of reduction necessary to accomplish the desired result could be determined it could not be constantly maintained, inasmuch as the peripheral resistance becomes, in great measure, rapidly restored.

For a number of years, in the course of various experiments in partial occlusion of the arteries, I had somewhat in view the chance of there being produced beyond the point of constriction a dilation of the artery analogous to that which had been observed in cases of cervical rib.

The Degree of Constriction and the Period of Time Required for the Production of the Dilation

Two years ago when, after many trials, I had altogether despaired of having the hope realized, I was startled, on examining the abdomen of a dog whose aorta had been constricted for 5 months and 20 days, to see that each of the branches of trifurcation was dilated almost to the size of the main aortic trunk. About to leave town for the summer, I communicated the finding to Dr. Reid, asking him promptly to repeat the experiment,

as precisely as possible. In the autumn we expectantly laparotomized three dogs upon which Dr. Reid had operated in the early summer and were disappointed to find that no change had taken place in the size of the aorta or its three terminal branches. Confident that there could have been no error in the original observation, I constricted the abdominal aorta, to various degrees, just above the trifurcation in twenty dogs and, at intervals, in

FIG. 34.—Aorta Before the Band was Applied.

FIG. 35.—Immediately After Application of Band.

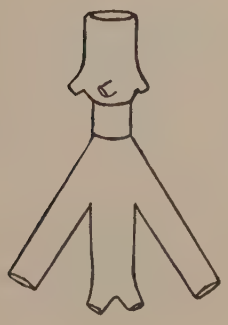


FIG. 36.—Two Months Thereafter.

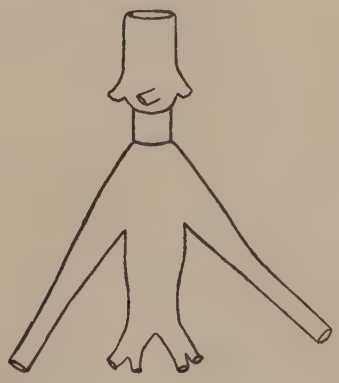


FIG. 37.—Six Months and 19 Days Thereafter.

FIG. 34-37.—Dog 7, Series I. (The Figures are Actual Size.)

the course of the winter, explored and reexplored the abdominal cavities, but with negative result, at least as concerned dilation.

Finally, on opening the abdomen of our last dog (No. 7) we found the dilation which we sought. The result is depicted in Figs. 34 to 37. The occlusion of the aorta in this case made 6 months and 19 days previously was almost complete, just as it had been in the one successful case of the foregoing year—I might say, of all the foregone years.

The pressure exercised by the band in this instance had been sufficient to lessen greatly, if not to obliterate, for a few moments at least, the palpable thrill produced by the constriction, but not enough completely to shut

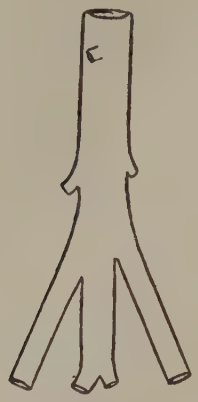


FIG. 38.—Aorta Before the Band Was Applied.

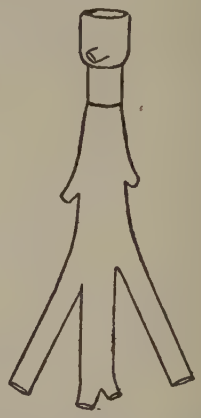


FIG. 39.—Immediately After Application of the Band.

FIG. 40.—97 Days Thereafter.

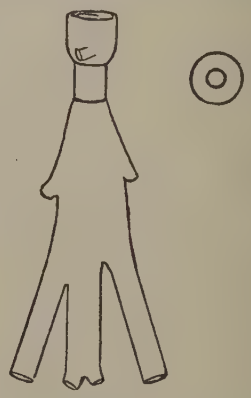


FIG. 41.—Nine Months Thereafter.
The outer of the two concentric circles indicates the circumference of the aorta at the site of the band before its application; the inner circles, the precise lumen of the aorta under the band when the dog was killed.

FIGS. 38-41.—Dog 3, Series II. (The Figures are Actual Size.)

off the palpable pulse. With this observation as a fresh incentive, Dr. Reid and I have continued the experiments during the current academic year with encouraging results.

If the occlusion must be so nearly complete in order to effect a well pronounced dilation, it will explain not only the difficulty we have had in producing it in dogs, but also the fact that it has been observed so seldom

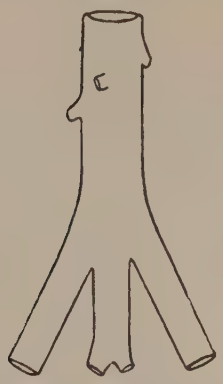


FIG. 42.—Aorta Before the Band Was Applied.

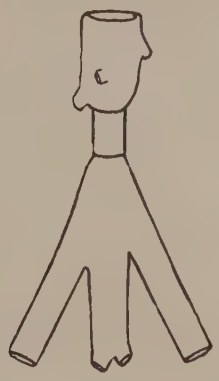


FIG. 43.—Immediately After Application of the Band.

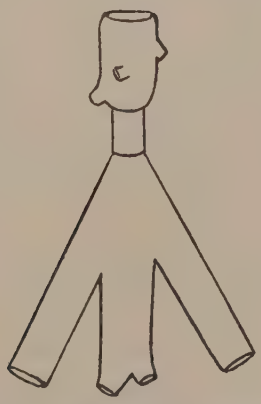


FIG. 44.—160 Days Thereafter. The outer of the two concentric circles indicates the circumference of the aorta at the site of the band before its application; the inner circle, the precise lumen of the aorta under the band when the dog was killed.

FIGS. 42-44.—Dog 15, Series II. (The Figures are Actual Size.)

in the human subject from compression of the subclavian artery by a cervical rib. For when in dogs the aortic pulse is occluded beyond the stage of palpable thrill the lumen is in danger of becoming obliterated, as by the formation of a cylindrical fibrous cord beneath the band, and thus

cancelling the experiment; and in the cervical rib cases we may assume argumentatively that the subclavian artery compressed to the stage sufficient to produce an aneurism might become thickened by sclerotic changes in the time required for the pronounced manifestation of a dilation. Thus, a moderate dilation, present for a brief period prior to occlusion of the subclavian, might be overlooked.

In dogs, a number of months must apparently elapse after the application of the band before a dilation in striking degree can occur. In the two cases (No. 7, 1913, and No. 7, 1914) to which reference has been made, 5 months and 20 days, and 6 months and 19 days, respectively, had elapsed. In the second of these, a dilation of the middle branch of the trifurcation of 2 mm., found at the expiration of 60 days, had increased to 4 mm. in the course of the following 4½ months (Figs. 34 to 37). Other instances of like dilation are accurately represented in Figs. 38 to 44. The amount of constriction made in two of the illustrated cases (Dogs 3 and 15, Series II) is indicated by the concentric circles of Figs. 41 and 44.

We have found and abstracted reports of 716 instances of cervical rib, in great part from the original.

Clinical cases	525
Autopsies	91
Museum specimens	100
Total	716

		Per cent
Cases with nerve symptoms alone	235	65.3
Cases with nerve and vascular symptoms	106	29.4
Cases with vascular symptoms alone	19	5.3
Total	360	

Five hundred twenty-five were clinical cases; 91, autopsy findings; and 100, museum specimens. Three hundred sixty presented symptoms of pressure. Of these, 235 had nerve symptoms alone; 106, nerve and vascular; and 19, only vascular symptoms. Accordingly we have reports of 125 cases of cervical rib in which vascular symptoms were noted. In 27 of these (21.6 per cent) an enlargement, fusiform, aneurismal, or cylindrical, was observed, and, of these, in the majority, the disturbance of circulation was severe, 6 cases having gangrene of fingers on the affected side (Table I).

Of the thirty dogs with aortic constriction upon which this report is based there was pronounced dilation, for a short distance, of the vessels below the band in seven, or 23.3 per cent.

It is interesting to note the correspondence in the human (21.6) and canine (23.3) percentages. We must not, however, overvalue the result of

this haphazard sort of comparison, for, as regards the human cases we have depended upon the impressions of surgeons, who, having no standards of comparison, having made no measurements, and not always being particularly concerned about the arterial feature of the case, may have overlooked or overestimated variations from the norm; and, as regards the thirty dogs, we observed, in addition to the seven designated as major dilations, ten minor ones. The seventeen dilations of all grades represent 56.6 per cent of the thirty dogs. The percentage is even greater if we include in our calculation only the dogs of the past year; and, for another year of experimentation, would probably be greater still.

We may, I think, conclude that the dilation of an artery produced experimentally is not due to any of the three factors proposed as causal for the aneurism in cases of cervical rib.

1. *Vasomotor Paralysis.*—(*a*) The vasomotor nerves and the vasa vasorum are destroyed by the moderately constricting and totally occluding bands quite as surely as by those which, occluding almost totally, alone have produced the dilation. (*b*) Only a portion of the circumference of the subclavian artery is exposed to the pressure of the cervical rib and the scalenus anticus muscle, and hence only a fraction of the vasomotor nerves or vasa vasorum could be pressed upon.

2. *Trauma.*—(*a*) Usually, the dilation is fusiform and (*b*) distal to the rib. (*c*) Trauma is excluded as a factor in the experimental dilations.

3. *Inconstant Blood Pressure.*—(*a*) Patients suffering from the pressure-pain of cervical rib rarely make wide excursion-movements of the arm. (*b*) The degree of occlusion is constant in the experimentally constricted vessel.

When an arterial trunk is ligated it becomes occluded to the first proximal and first distal branches by a process of cell proliferation which ultimately reduces the artery to a fibrous strand.

Is There a Fall in Blood Pressure in the Dead Arterial Pocket Which May Anticipate and Possibly Be a Causative Factor in the Obliteration of This Portion of an Artery?

From observations which I have made on man and dogs I am quite sure that there may be a remarkable fall in blood pressure in what I have termed the "dead arterial pocket," while there is still little if any sign of diminution in the calibre of this portion of the vessel. For example, the right common carotid artery was ligated by the writer in a case of aneurism of the external carotid. About 3 months later, in the course of an operation for the excision of the uncured aneurism, the internal carotid, dead-pocketed between the circle of Willis and the carotid ventricle, was freely exposed for a considerable distance. It had lost its cylindrical form, being flat and

tape-like, and, although evidently possessing a considerable lumen, seemed to be empty. When pricked, a few drops of blood oozed without pulse from the little cut. The artery was then resected between two ligatures. Its wall was thickened on one side (Plate XXXI, 1) but the lumen was still perhaps three times that of a radial artery. Similar observations I have made twice on the external iliac artery of the dog after occlusion of this vessel at its origin from the aorta. In the approximately dead pocket between the aorta and the origin of the circumflex iliac and common trunk of the epigastric and obturator arteries the blood pressure must have been almost nil, because from a little slit made in the apparently normal arterial wall of the relatively empty external iliac artery the blood escaped very slowly in a tiny, almost pulseless jet about 1 cm. high; whereas, from the femoral artery, below the profunda, the blood spurted normally from a similar knife-prick.

Hence in an artery doomed to obliteration, it would seem that the blood pressure may be lowered before the occlusion process sets in—the lowered pressure being, perhaps, the immediate factor leading to the obliteration.

Consideration of the Cause of the Dilation

Can these observations have any bearing upon the explanation of the dilation of the aorta above its trifurcation, of its triad branches, and of the carotid, which we have occasionally observed in the dog distal to the partially occluding band?

The mechanical engineer knows the effect upon pressures of constricting a rigid tube through which water is being forced at a given pressure. At the site of the constriction, of the Venturi meter, the pressure is diminished and the velocity increased, whereas immediately beyond the constriction both the normal pressure and velocity are restored. This is not, however, true of the constricted arterial tube. Beyond the band the systolic pressure may be lowered, the diastolic pressure increased, and the pulse pressure greatly reduced for many months at least.

If the constriction of the aorta is very slight the effect upon the blood pressures is usually transient, the normal pressures being reestablished within a few hours or, indeed, minutes. But if the artery is constricted to the point of almost total occlusion the pulse pressure below the band, for a time almost nil, may remain lowered and the diastolic pressure, relatively or even actually, be increased. The blood stream in this case, passing with greater velocity and less pressure through the band prevents the obliteration of the artery to the nearest branch, the pocket being not a dead one as it is in the case of total obliteration. The blood in this pocket beyond the constriction streams in whirlpools, somewhat as in the vein and, also, as in the

artery in arterio-venous fistula; the thrill, not palpable at first, later may be perceived with the finger; and the bruit, always audible with the stethoscope, becomes louder as the peripheral arterial resistance increases.

To these factors, then—to the abnormal play of the blood in the relatively, as distinguished from the absolutely dead pocket and to the absence of normal pulse pressure, essential probably to the maintenance of the integrity of the arterial wall—we may have to look for the solution of our problem.

It is not, however, denied that the paralysis of the vasomotor nerves and the occlusion of the vasa vasorum may possibly play some part in the manifestation. The dilations produced experimentally, like those observed in cases of cervical rib, are, as I have said, circumscribed. We had conjectured that the delimitation of the dilation might be influenced or determined by the location of the branches of the affected artery beyond the constriction. In one instance, however, we observed, just distal to a partially occluding band applied to the carotid low in the neck of a dog, a circumscribed dilation of this vessel, the branches of which had been tied and divided. In this case there was a long stretch of debranched and patulous carotid between its dilated portion and the base of the skull.

Do Intimal Surfaces Brought Gently in Contact Unite, and What Is the Process by Which Obliteration of an Artery Takes Place after Occlusion by Band or Ligature?

The intimal surfaces of arteries brought intact in apposition whether by ligature or by band never, in my experience, have united. This statement will be received sceptically, for it is at variance with the quite universally accepted view, that uncrushed intimal surfaces if brought gently in contact adhere and thus occlude the artery. In the ligation of the larger arteries we have been taught to use heavy ligatures, two or three abreast, and in tightening them to employ only enough force to bring the intimal surfaces in contact, a force not sufficient to rupture or injure the intimal coat. The gross and microscopic findings in the sections of arteries ligated in this manner have been repeatedly portrayed, but the illustrations submitted as proof are not convincing.
organization.

It is my opinion that the pressure necessary to bring about the complete closure of the aorta causes atrophy of the arterial wall under the band, and that union of the apposed surfaces thus deprived of their blood supply does not occur. To accord with this view, how is to be explained the formation of the fibrous cylinder which we occasionally find encompassed by the band, and how the probable error of other investigators who believe that intimal

surfaces brought gently in contact by broad ligatures unite primarily and thus interrupt the blood stream?

The process of occlusion is, I believe, somewhat as follows: The death of the arterial wall having been brought about by the pressure of the band, a gradual substitution or organization of the necrotic tissue takes place, the new blood vessels penetrating it from both ends. The absorption of the lifeless wall proceeds coordinately with its vascularization or organization.

If the band has been rolled so tightly as to occlude the lumen, the arterial wall is deeply puckered or plicated. If after a month or two the aorta is cut open at this point, the folds of the arterial wall may still be seen. They will not be adherent to each other, but atrophied possibly to the thinness of writing or tissue paper. The attenuated wall can still be completely unfolded. In some cases it is found to be abnormally thick and a very fine lumen to have been established (Plate XXXII, 1). In this event there are no folds, the thick wall consisting altogether of new tissue, and the old wall with its plication having been absorbed. Consequent upon the atrophy of the arterial wall the tension under the band is eliminated, capillaries sprout into the necrotic part, which thus becomes replaced by new connective tissue. A tiny blood stream may make its way under the band, and an endothelial lining for the new wall develop.

More often we find in the completely or almost completely occluded cases that a solid, fibrous, cylindrical cord completely fills the space within the band and replaces the original wall of the artery.

Although we are unable to share the opinion of other investigators that the uninjured intimal surfaces of large arteries adhere to each other when brought in contact, the advice to bring broad surfaces in apposition by several contiguous, coarse ligatures is good. We have found that the finer the ligature the quicker it cuts through the artery, very fine silk cutting through in a day or two. Narrow tape, constricting the artery in spiral or cuff-like form, has about the same effect upon the arterial wall as the metal band. Under three or four coarse ligatures, drawn tightly enough to occlude the lumen but not so tightly as to injure the intima, the arterial wall would behave presumably as it does under the tape or band, and occlusion take place in the described manner. I should think, however, that it would be impossible in a given case to be sure that each one of three ligatures, for example, had occluded the artery without injury to the intima. Even with the metal band, which can be rolled with great precision and in perfect, cylindrical form, it is not possible to say that occlusion has no more than just been attained, although we can be certain that the intima has suffered no trauma. But with the ligature pressure cannot be exerted in such fine

and exact gradations; there is also the complication of the knot and its particular pressure.

The surgeon's conceptions as to the finer processes concerned in the occlusion of arteries after ligature are based largely upon studies undertaken before the days of perfected asepsis, in the days when thrombus formation almost invariably complicated the picture.

Summary

1. A partially occluded artery may dilate distal to the site of constriction.

2. The dilation is circumscribed.

3. When the constriction has been either slight in amount or complete, dilation has not been observed.

4. The dilation was greatest when the lumen of the artery (the aorta) was reduced to one-third or perhaps one-fourth of its original size (Figs. 41 and 44).

5. Dilation or aneurism of the subclavian artery has been observed twenty-seven or more times in cases of cervical rib.

6. The dilation of the subclavian is circumscribed, is distal to the point of constriction, and strikingly resembles the dilation which we have produced experimentally.

7. The genesis of the experimental dilation and of the subclavian dilation occurring with cervical rib is probably the same.

8. When the lumen of the aorta is considerably constricted the systolic pressure may be permanently so lowered and the diastolic pressure so increased that the pulse pressure is greatly diminished.[4]

9. The experimentally produced dilations and the aneurisms of the subclavian artery in cases of cervical rib are probably not due to vasomotor paralysis, trauma, or sudden variations in blood pressure.

10. The abnormal, whirlpool-like play of the blood in the relatively dead pocket just below the site of the constriction, and the lowered pulse pressure may be the chief factors concerned in the production of the dilations.

11. Intimal surfaces brought, however gently, in contact by bands or ligatures do not, in our experience, unite by first intention, for the force necessary to occlude the artery is sufficient to cause necrosis of the arterial wall.

12. Bands, rolled ever so tightly, do not rupture the intima.

13. The death of the arterial wall having been brought about by the pressure of the band, a gradual substitution of the necrotic tissue takes place, the new vessels penetrating it from both ends. It is, I believe, in this manner that an artery becomes occluded, and it is thus that a fibrous cord forms within the constricting band.

[4] See Reid, M. R., J. Exp. Med., 1916, xxiv, 287.

TABLE I.—CASES OF DILATION OF THE SUBCLAVIAN ARTERY WITH CERVICAL RIB

Surgeon.	Publication.	Note on dilation of subclavian artery.	Remarks.
Mayo, H.	*London Med. and Phys. J.*, 1831, N. S., xi, 40.	Right subclavian artery flattened. Unusual width.	
1. Adams, R.	*Dublin J. Med. Sc.*, 1839, xv, 494.	Ovoid dilation of 3d portion, left subclavian, about size of pigeon's egg. Postmortem confirmation.	Radial pulses equal.
2. Warren, J. M.	*Am. J. Med. Sc.*, 1849, xvii, 13.	Aneurismal tumor, left subclavian, about size of pigeon's egg.	Dec. 24, 1847. Ligation of 3d portion. Ligature came away on 96th day.
3. Coote, H.	Lancet, 1861, i, 360.	Pulsating swelling of left subclavian, about size of walnut.	Part of cervical rib resected. Radial pulse hardly palpable before operation.
4. Poland, A.	*Med.-Chir. Tr.*, 1869, lii, 277.	Right subclavian—"Circumscribed dilatation of entire circumference."	"Digital compression on cardiac side of tumor for 96 hours." Cure of aneurism.
5. Baum, W.	*Deutsch. Chir.*, 1880, Liefg. 34, 25. (Fischer, G.)	"Left subclavian aneurism."	Ice, elevation of arm, compression. Aneurism cured. Pulse absent in radial and ulnar, but present in brachial.
6. Gould, A. P.	*Tr. Clin. Soc.*, 1884, xvii, 95.	"Right subclavian artery projected even beyond clavicle as tense pulsating cylinder."	No operation. Progressive obliterative arteritis. Dilation uninfluenced.
7. Morris, W. C.	*Lancet*, 1885, ii, 152.	Fusiform aneurism of right subclavian, $\frac{3}{4}$ in. in width.	Operation. Central ligation of 3d portion. Radial pulse before operation weak—absent after operation—but reappeared in 1 month or less.

* Karg.	*Beitr. klin. Chir.*, 1895, xiv, 215. (Ehrich, E.)	Aneurism of left subclavian appeared after removal of the cervical rib.	Artery compressed between 2 cervical ribs. Both ribs removed. Aneurism cured by compression.
8. Stifler.	*Münch. med. Woch.*, 1896, xliii, 544.	Pulsating tumor of left subclavian. Sudden appearance.	Blood pressure, left 120; right 140. No operation.
9. Cohen, J.	Inaug. Diss., Göttingen, 1898.	"Left subclavian aneurism size of plover's egg."†	"Weaker radial pulse." Fusiform dilation.—"7 cm. long and 1½ fingers thick." Aneurism excised.
10. Grisson.	*Fortschr. Geb. Röntgenstrahlen*, 1898-99, ii, 103.	Right subclavian, "pulsating cord, thickness of little finger."	Pulseless axillary, brachial (hard cord), and radial. Aneurism cured by suspension, Priesnitz bandage, etc.
11. Winkler, C.	*Nederl. Tyschr. Geneesk.*, 1904, xl, 589; *Münch. med. Woch.*, 1904, li, 2111.	Left subclavian—"Locally aneurismally dilated."	Cyanosis of left hand.
12. Murphy, J. B.	*Ann. Surg.*, 1905, xli, 399.	Left subclavian "flattened and circular."	Brachial and radial pulses normal with arm extended. Operation. Dilation questioned by author in 1905, but called abnormal dilation in 1906.
? Murphy, J. B.	*Surg. Gynec. and Obst.*, 1906, iii, 514.	Right subclavian flattened out on surface of rib.	(Circulation?) Dilation questioned by author. (Exophthalmic goiter.)
13. Conner, L.	*Med. Rec.*, 1906, lxix, 775.	Left subclavian—"Broad pulsating mass suggestive of aneurism."	No note as to circulation or treatment.

TABLE I.—CONTINUED

Surgeon.	Publication.	Note on dilation of subclavian artery.	Remarks.
14. Keen, W. W.	*Am. J. Med. Sc.*, 1907, cxxxiii, 173.	Left subclavian dilated to nearly twice width of artery.	Gangrene. Operation. Cylindrical dilation to clavicle or beyond.
? Russel, C. K.	*Med. Rec.*, 1907, lxxi, 253.	*Autopsy Note.*—Right subclavian proximal to thyroid axis, large and soft; distal to this, contracted and cord-like. Left subclavian enlarged.	Gangrene. Amputation of index finger, and later of arm. Patient would not consent to operation on rib. Suicide.
? von Heinecke, W.H.	Inaug. Diss., Erlangen, 1907, 40. (Deitmar.)	Left subclavian "surprisingly broad." (Operative note.)	Left radial pulse weaker than right, not improved by resection of rib.
* Halsted, W. S.	Unpublished (1909).	Dilation of right subclavian developed after removal of cervical rib.	The aneurism, size of plover's egg, seemed to involve the artery central to the site of constriction.
15. Hamann, C. A.	*Cleveland Med. J.*, 1910, ix, 453.	Right subclavian beyond rib enlarged and filled with clot.	Gangrene of fingers. Bursa ¾ in. in diameter between artery and rib. Resection of part of the rib.
16. Pringle, J. H.	*Edinburgh Med. J.*, 1911, vii, 253.	Left subclavian—fusiform aneurism distal to rib—sacculated at its proximal part under outer edge of scalenus.	Aneurism twice needled (before discovery of rib). Finally opened and rib removed. Radial pulse "feebler"; became fair after operation.
17. Miller, J. L.	*Am. J. Med. Sc.*, 1911, cxlii, 811.	Side not stated. Slight dilation above the notch in cervical rib.	Cyanosis of hand.

Galloway, J.	*Proc. Roy. Soc. Med.*, 1911-12, v, 112.	Left subclavian—"pulsating tumor."	Unoperated.
? Seymour, N. G.	*Am. J. Med. Sc.*, 1913, cxlvi, 396.	Right subclavian—small pulsating tumor, "simulating" aneurism.	Female, 16 years. Radial pulse unaffected.
18. Law, A. A.	*J.-Lancet*, 1914, xxxiv, 333.	"Right subclavian dilated distal to rib." "Left subclavian flattened."	Gangrene of fingers. Resection of rib on both sides.
19. Potter, C.	*J. Missouri Med. Assn.*, 1914-15, xi, 74.	Left subclavian—"Pouch-like dilatation of the wall of the artery over groove in cervical rib."	Male, 17 years. Ulcers and gangrene of thumb and ring finger. Brachial and radial pulses absent.

* In the unnumbered cases the dilation is questionable. In the cases marked with an asterisk the aneurism appeared after removal of the rib.

† Possibly due to fracture of the clavicle.

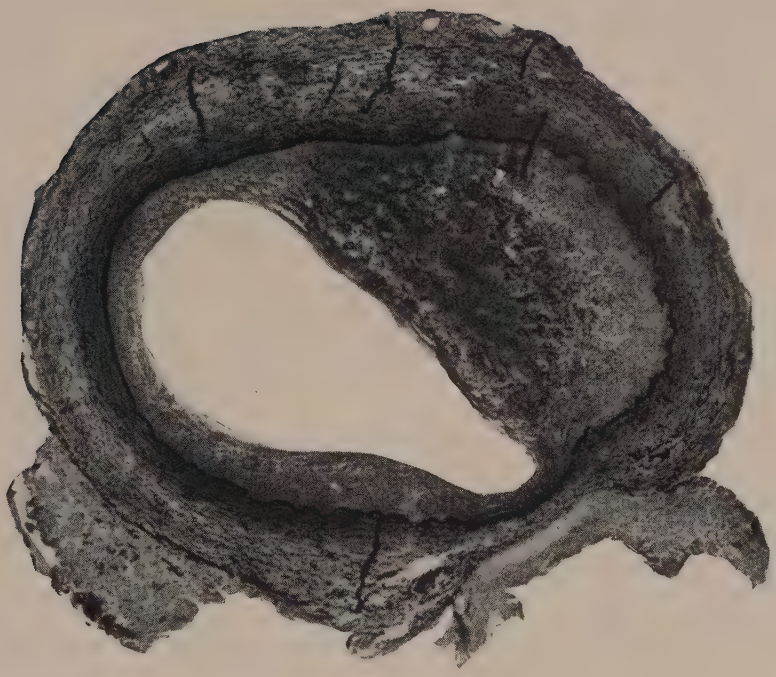
EXPLANATION OF PLATE

SECTION OF HUMAN INTERNAL CAROTID

1. Section of human internal carotid, showing the process of obliteration after ligation of the common carotid. When removed at a subsequent operation this artery was found pulseless and almost empty notwithstanding the size of its lumen. × 25.

DOG 9, SERIES II. (THE FIGURE IS ACTUAL SIZE)

2. The band was rolled so tight as to shut off the palpable thrill but not the pulse. When killed after 6 months and 8 days the lumen at the lower edge of the band was 1.2 mm. in diameter. A new wall had been formed under the band, thick throughout, but particularly so at the lower and upper borders of the band. It is probable that, in this case, a fibrous cord ultimately would have formed.



1.

2.

PARTIAL OCCLUSION OF THE AORTA WITH THE METALLIC BAND

OBSERVATIONS ON BLOOD PRESSURES AND CHANGES IN THE ARTERIAL WALLS[1]

In all except one of the aortic experiments of Dr. Halsted and myself the constricting aluminum band was applied to the abdominal aorta below its inferior mesenteric branch. At the time of our final observations on these animals records were made of the blood pressures in the femoral and carotid arteries. Obviously, in order to draw any conclusions as to the effect of the band on the blood pressure below the site of the constriction, the normal relation between the pressures in these two vessels must be known.

In a series of experiments performed by Dr. Dawson on dogs, it was learned that the pulse pressure in the femoral artery is normally about twice as high as in the carotid. The femoral systolic pressure is higher and the diastolic pressure lower than the corresponding pressures in the carotid artery (Fig. 45).

After partial occlusion of the aorta the systolic pressure in the femoral is markedly lowered. This lowering of the systolic pressure is due mainly to a fall in the pulse pressure, for the diastolic pressure remains almost stationary, or may be actually increased. In the cases of most marked dilation the femoral pulse pressure was only about one-half the carotid pulse pressure, while the femoral diastolic was actually greater than the carotid diastolic pressure (Fig. 46).

During the first hour after the application of a moderately tight band the femoral pressures undergo marked changes. At first the systolic and diastolic pressures are both lowered. In a few minutes the diastolic pressure may become even greater than before the application of the band, while the systolic is still subnormal (Fig. 47).

After complete occlusion of the aorta the normal blood pressure relation between the femoral and carotid arteries may, ultimately, in some instances, be reestablished.

[1] By Mont R. Reid.

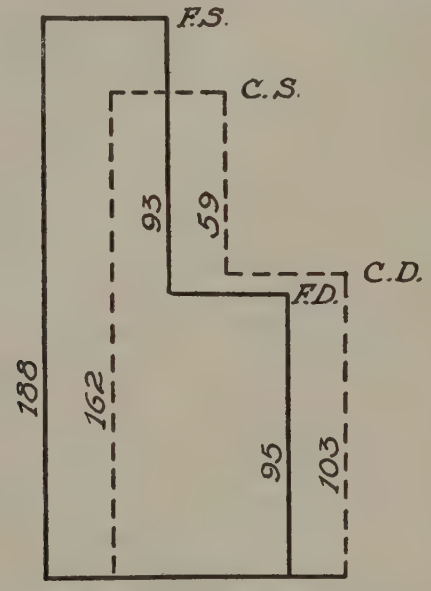
This communication is to supplement Dr. Halsted's paper, "Circumscribed dilation of an artery immediately distal to a partially occluding band," which was published in J. Exper. M., Balt., 1916, xxiv, 271-286.

Received for publication June 27, 1916.

J. Exper. M., Balt., 1916, xxiv, 287-290. (Reprinted.)

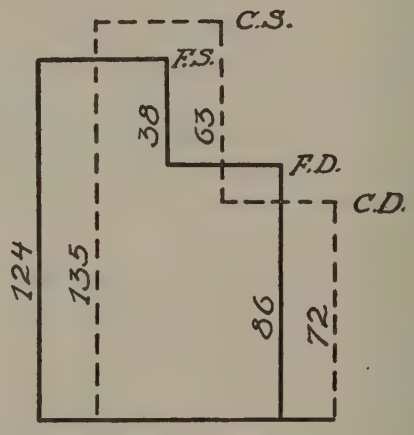
Gross Effect of the Band on the Vessel Wall.—In some cases in which the band has been loosely applied, only slight gross alteration in the wall of the vessel under the band is found, even after six months. On removal of the band the plications of the wall can be unfolded, and the intima presents a normal looking, smooth surface (Plate XXXIII, 1).

In the majority of cases there occurs an atrophy or necrosis of the vessel wall included in the band. In some cases the band had made its way through the atrophic wall into the lumen of the vessel (Plate XXXIII, 2



F.S. 188. F.D. 95. Pulse pressure 93.
C.S. 162. C.D. 103. Pulse pressure 59.

FIG. 45—The normal relation between the systolic and diastolic end pressures in the femoral and carotid arteries of dogs.



F.S. 124. F.D. 86. Pulse pressure 38.
C.S. 135. C.D. 72. Pulse pressure 63.

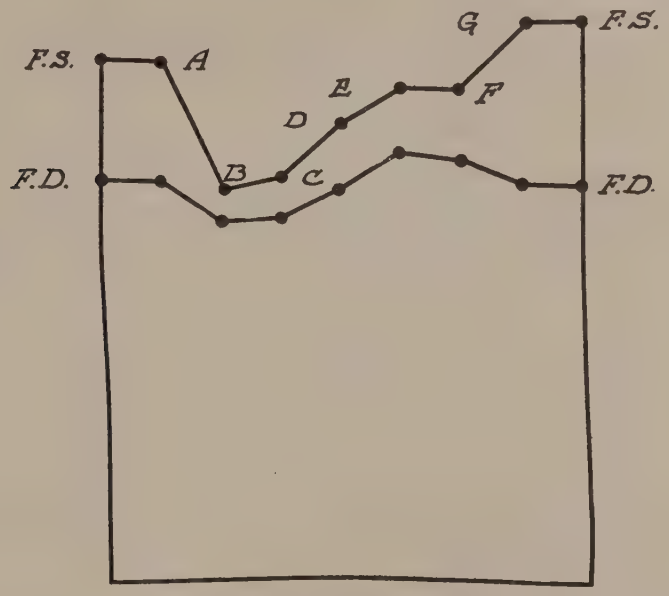
FIG. 46.—Systolic and diastolic end pressures in Dog 7, Series I, six months and 10 days after the band was applied. Good dilation.

and 3, and Plate XXXIV, 1); in these a new wall had formed outside the band. In no instance was there leakage of blood. On splitting open the artery for examination the band is seen, more or less distinctly, shimmering through the atrophic arterial wall. This wall may be attenuated to a veil-like thinness or, as described, may, in places, have entirely disappeared, disclosing portions of the band. The upper edge of the band, at the posterior surface of the arterial wall, is almost invariably the first part to be exposed (Plate XXXIII, 2 and 3).

Histologic Changes.—For a short distance below the site of the band there is usually a definite atrophy of the elastic and muscular tissues. In

Case 7, Series I (Plate XXXIV, 2, *c*), there was almost a complete break in the elastic tissue below the edge of the band. The connective tissue throughout the wall of the artery seemed to be little affected in amount in the dilated portion of the vessel.

At the site of the band the new wall that forms over it is composed mainly of fibrous tissue (Plate XXXIV, 1, and Plate XXXV). Thus far, none of our cases have shown regeneration of the elastic tissue in this new wall.



A. Without band 175, 135.
B. Immediately after band was applied 131, 121.
C. 5 minutes later 135, 123.
D. 25 minutes later 155, 133.
E. 35 minutes later 167, 144.
F. 35 + minutes later 167, 143.
G. Band removed 189, 138.

FIG. 47.—Systolic and diastolic end pressures in the femoral artery during the first 35 minutes after a tight band was placed around the aorta.

In the fibrous cord (Plates XXXVI, XXXVII and XXXVIII) which occasionally forms under the tightly rolled band no remains of the vessel wall have been found. We think it probable that the original arterial wall undergoes complete atrophy and absorption in these cases, and that the cylindrical cord found under the band consists of new tissue which, growing in from above and below, replaces the old. This cylindrical fibrous cord may be highly vascularized (Plate XXXVIII). We have found no evidence of union between the apposed intimal surfaces.

EXPLANATION OF PLATES

Plate XXXIII

1.—Dog 9, Series I. The band was rolled to the early stage of palpable thrill. The band in 6 months has produced only slight thinning of the vessel wall.

2.—Dog 7, Series II. Marked constriction. The thrill was not obliterated. The band had, in 6 months, cut entirely through at its upper edge, posteriorly. At the lower edge of the band there is still a remnant of the atrophied wall (compare Plate XXXIV, 1).

3.—Dog 0, Series II. The band was tightly rolled but not totally occluding. At autopsy, 5½ months later, the lumen under the band was about 3 mm. in diameter. The aortic wall was so thin that the band shimmered through it everywhere, and had cut through at several places along the upper and lower edges. A new arterial wall, almost complete, had formed outside the band.

Plate XXXIV

1.—Dog 7, Series II. Longitudinal section through the arterial walls, old and new (compare Plate XXXIII, 2). Weigert's elastic tissue stain. *a* is the site of the band; *b*, elastic tissue of the aortic wall proximal to the band; *c*, elastic tissue distal to the band; *e*, the new wall which had formed outside the band where it had cut through, posteriorly. Between *a* and the lumen of the vessel the original wall is greatly thickened.

2.—Dog 7, Series I. The band was tightened until the thrill disappeared; the pulse was not obliterated. Killed after 6 months and 19 days. Longitudinal section through the arterial wall at the site of the band. Weigert's elastic tissue stain. In this case there was marked dilation below the band. *a* is the site of the band; *b*, the aortic wall proximal to the band; *c*, the aortic wall distal to the band, showing definite atrophy and a break in the elastic tissue; *e*, the new wall that had formed outside the band; *x* to *x*, the segment of the vessel wall that had been included by the band. In this segment there is marked atrophy of the elastic tissue, particularly at the edges of the band.

Plate XXXV

Dog 17, Series I. The band was tightened to the vanishing side of the thrill stage. Longitudinal section through the arterial wall at the site of the band. Weigert's elastic tissue stain. Under the band the elastic tissue is rarified. Below the band, where there was a moderate amount of dilation, atrophic changes are noted. *a* is the slit occupied by the band; *b*, the vessel wall proximal to the band; *c*, the vessel wall distal to the band.

Plate XXXVI

Dog 2, Series I. The band was tightened until the pulse had just disappeared. When examined after 7 months, a solid fibrous, cylindrical cord was found under the band.

Plate XXXVII

Dog 2, Series I. Longitudinal section through the fibrous cord shown in Plate XXXVI. Weigert's elastic tissue stain. *a* is the site of the band, under it the elastic tissue has vanished; *b*, the vessel wall proximal to the band; *c*, the vessel wall distal to the band, showing definite atrophy of the elastic tissue; *d* to *d'*, the fibrous cord; *e*, fibrous tissue that formed about the band. There is almost complete disappearance of the elastic tissue at the site of the band.

Plate XXXVIII

Dog 2, Series I. Transverse section of the fibrous cord through *d*, Plate XXXVII. Hematoxylin and eosin.

1.

2.

3.

PLATE XXXIV

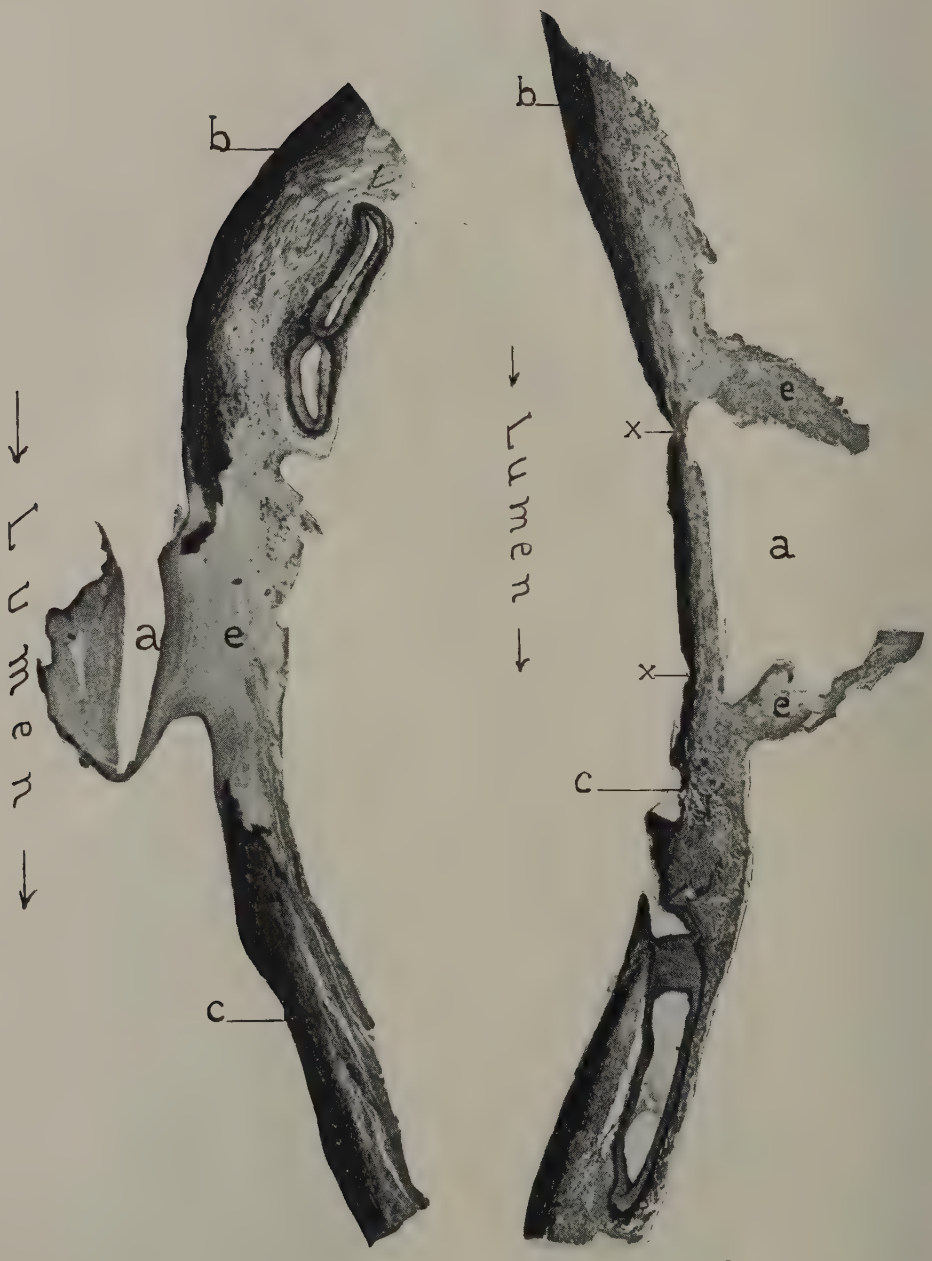


PLATE XXXV

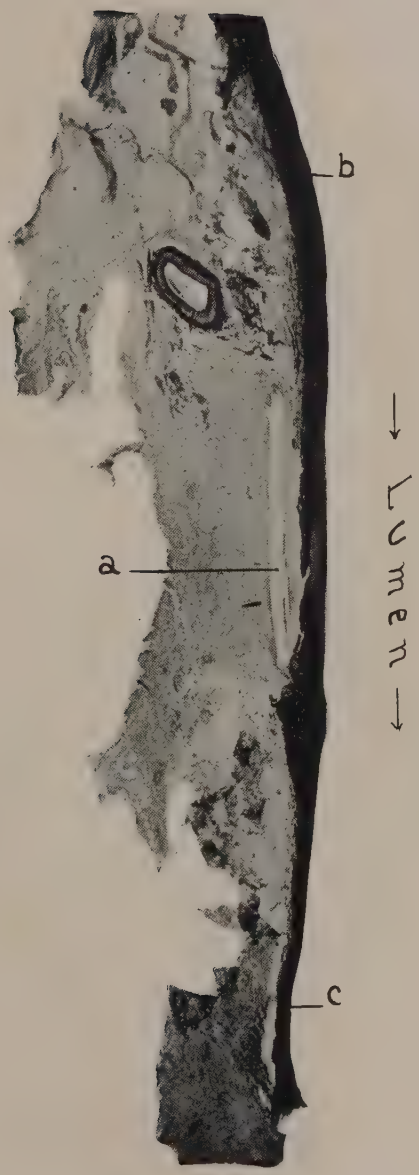


PLATE XXXVI

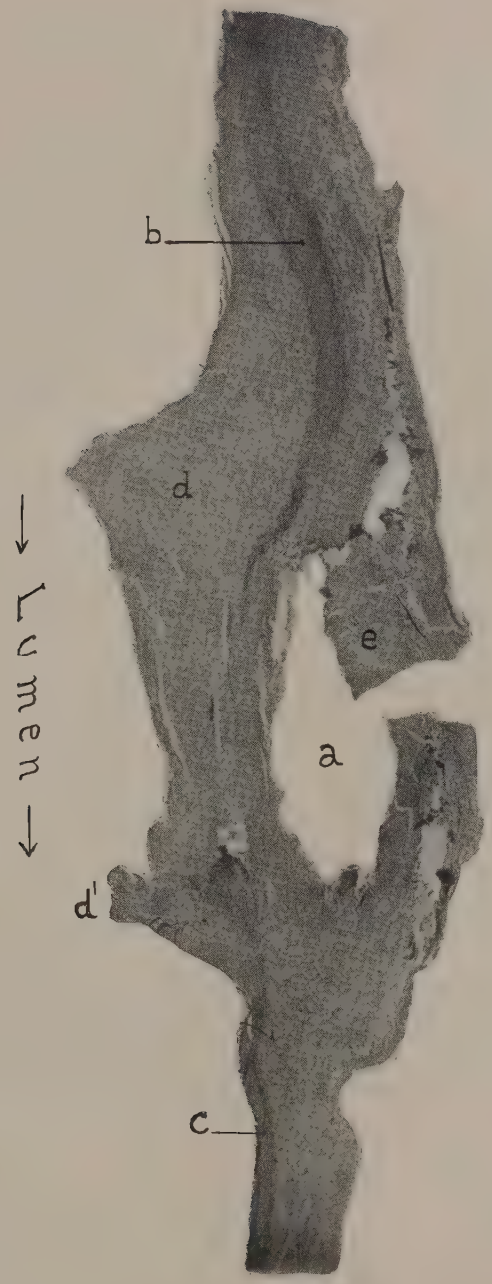
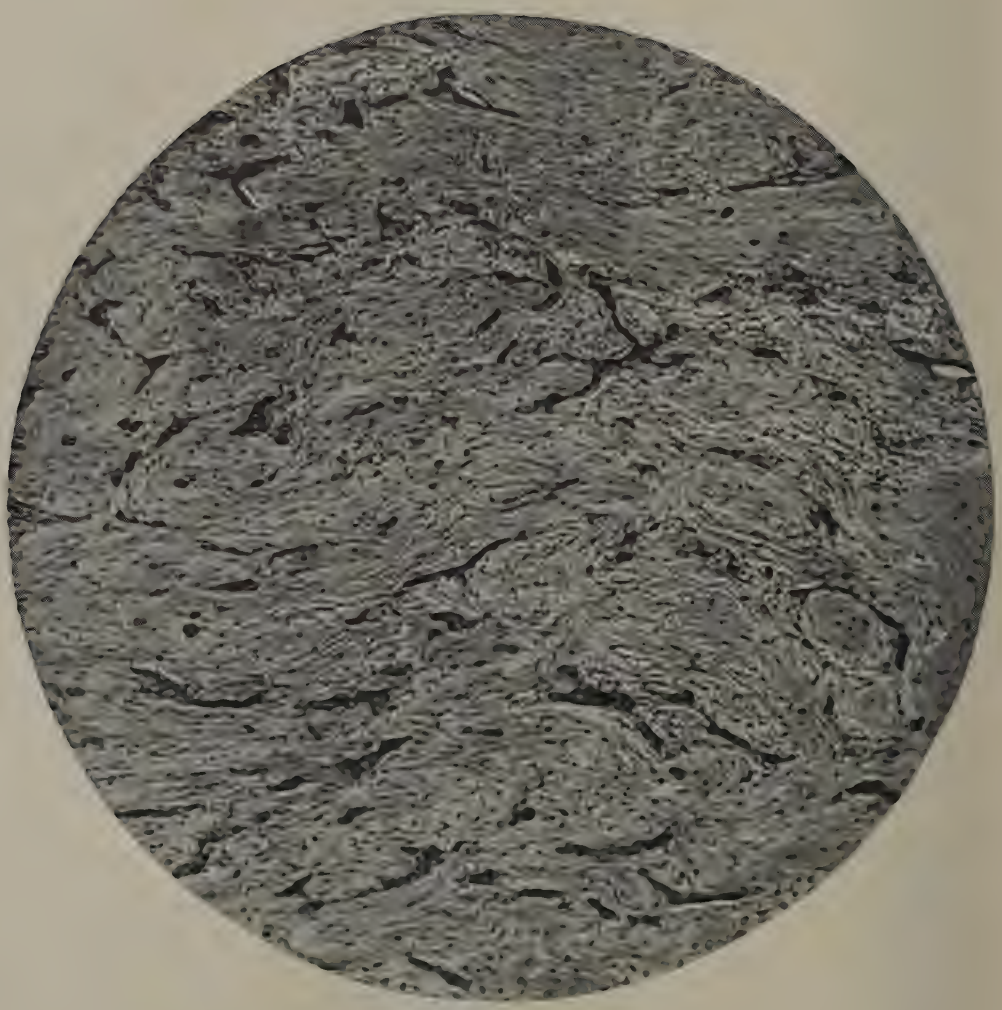

b
d
e
a
d'
c
Lumen

PLATE XXXVIII



THE IDEAL OPERATION FOR ANEURISM; A CASE OF LYMPHANGIOMATOUS CYST[1]

Dr. Bernheim is to be congratulated greatly. The indications for the transplantation seem to have been clear, and the operation was a complete success. It is well termed the "ideal operation," when the indications for transplantation are so definite as they were in the case just reported by Dr. Bernheim.

We are indebted to Alexis Carrel for making such an operation possible. Professor Lexer, the distinguished director of the surgical clinic of the University of Jena, is responsible for the term, and he was probably the first to transplant a blood vessel in the treatment of aneurism. Many surgical procedures have been called "ideal," and for their time have, perhaps, deserved the appellation. Most of them were, however, short-lived. Some surgeons, myself[2] in the number, have advocated excision of the aneurism under certain conditions. By Bramann and by Delbet excision was termed the "ideal operation." Lexer reported his first case at a meeting of the Deutsche Gesellschaft für Chirurgie eight or nine years ago. The operation was for an aneurism in the axilla, the result of an attempt by some surgeon to reduce an old dislocation of the shoulder-joint. The operation was successful so far as concerned the patency of the vessels; but the patient died in a few days of delirium tremens.

Four or five years later Lexer reported a second case, also successful. In this a long piece of the saphenous vein was transplanted into the defect caused by the excision of a popliteal aneurism. Lexer has performed his "ideal operation" in a third case, the details of which I cannot at this moment recall. In several other instances in the human subject the transplantation of a vein to replace an arterial defect has been undertaken, usually with unsuccessful result. The surgeon who attempts this operation without having practised it on animals will almost surely fail to accomplish it successfully.

Six years ago I invited Dr. Bernheim to transplant for me a long piece (12 to 14 cm.) of the saphenous vein into an arterial defect caused by the excision of a sarcoma of the popliteal space. In this case the popliteal vein,

[1] Remarks in discussion of Dr. Bertram M. Bernheim's paper, "The Ideal Operation for Aneurism of the Extremity: Report of a case." The Johns Hopkins Hospital Medical Society, Baltimore, October 18, 1915.

Johns Hopkins Hosp. Bull., Balt., 1916, xxvii, 94-96.

[2] Ligation of the first portion of the left subclavian artery and excision of a subclavioaxillary aneurism. Johns Hopkins Hosp. Bull., 1892, iii, p. 93.

the internal popliteal nerve and the popliteal artery, from Hunter's canal almost to its bifurcation into the tibials, had been excised. The vascular suture at the lower end of the space was quite difficult on account of the depth of the wound and the relatively small size of the distal stump of the artery. For a time the circulation through the transplant was perfect, but the interpolated vein became thrombosed [3] before the wound could be closed. Gangrene did not, however, ensue.

I might mention in this connection that an end-to-end suture of the aorta has been successfully accomplished. In excising a retroperitonaeal tumor, Braun tore into the abdominal aorta, and after excising about 2 cm. of this artery, was able to sew the widely separated ends together.

Professor Kümmel, of Hamburg, told me of a recent interesting experience of his own. On excising a tumor he made a hole in the abdominal aorta. This he closed with a suture of coarse silk and, if I remember correctly, without the use of oil or vaseline. A second uninterrupted suture of fine silk was taken to reinforce the first.

I should like to be the first to call attention to a possible flaw in my argument for practising the partial occlusion of an artery in the treatment of certain cases of aneurism. As some of you perhaps know, I advocate the employment of a band which can readily be removed and which does not injure the wall of the artery, in order to test and then to encourage the anastomotic circulation. But I realize that it may be possible, even with only partial occlusion, to interrupt the blood flow totally and too quickly. Thus, following the application of a band which still permits a small stream to flow through the artery to the aneurism, the latter might so promptly become solidified by the clotting of its contents that gangrene should be threatened. It is obvious that in such a case removal or loosening of the band might not restore the circulation through the aneurism.

My own experience with vascular suture in the human subject has extended only to veins and to the lateral suture of a defect of the femoral artery in Hunter's canal.

Of particular interest to me is the case of a patient upon whom, with the assistance of Dr. Heuer, I operated four or five years ago. We had about completed the removal of a very large lymphangiomatous cyst of the

[3] The most serious objection to the "ideal" or vein-grafting operation is perhaps this: that in case of failure the thrombosis which starts in the graft may extend either centrally or peripherally, or in both directions, from the interpolated vein into the artery and thus involve important anastomotic branches which would not have been threatened with occlusion if the artery had been merely ligated, or the sac merely excised or plicated. The transplanted vein is, consequently, a menace, for in at least two-thirds of the cases in which the "ideal operation" has been practised, thrombosis has occurred in the insert.

abdomen. There remained to be freed only its connections with the inferior vena cava. While these were being separated with extreme caution, blood gushed from this vein. There proved to be a linear defect in the vena cava so long that six artery clamps were required to close it. A lateral suture of the vessel with oiled, fine silk was successfully accomplished. The patient's convalescence was uneventful and she is at the present time in excellent health. The defect in the wall of the vein was not an artefact. It represented, I believe, an imperfectly closed orifice from the vein to a lymph-bud or lymphatic vessel from which the cyst had had its origin. I expect to report, later, this case and an analogous one, in detail, because they may serve to account for the occasional presence, hitherto unexplained, of blood in certain lymphangiomatous cysts, and for the observations that cysts which on the first tapping yielded a clear fluid have, on subsequent tappings, been found to contain more or less blood.

Thus Professor Jordan and Professor Voelcker[4] of Heidelberg refer to a case of cyst of the neck, reported by Weil, which had its origin, he believed, in a haemorrhage from the vascular wall of a cystic lymphangioma. In support of Weil's view, the authors instance the observations, repeatedly made, that cysts from which at the first puncture only a clear serous fluid was withdrawn at subsequent aspirations sometimes yielded blood. And one frequently meets with the statement that the serous content of lymphangiomatous cysts may *after injury* become bloody.

As a possible explanation of the occasional presence of blood in lymphangiomatous cysts I would suggest that a primordial communication between the vein and the lymphatic cyst may not have been completely closed. The presence of blood, at subsequent aspirations, in the content of the cysts, which at the first tapping had yielded only a clear serum, might be due to the relief of tension in the cyst rather than to an injury of its wall; for the pressure within the cyst being diminished or negatived, there might be a retrograde flow of blood from the original venous connection.

In one of my cases, a supraclavicular hygroma, a definite relation to a large vein of the neck was demonstrated, and in the other, as I have related, there was an intimate connection with the inferior vena cava and evidence of an opening between the cyst and the vein which may have become closed more or less completely by a cribriform fascia of some sort. It is, I believe, very improbable that the thin nonvascular walls of either of these lymphangiomatous cysts could have contributed much, if indeed any, blood to their contents; and to continuously furnish blood enough to stain the fluid for possible frequent subsequent tappings would, it seems to me, have been, for such walls, impossible.

[4] Handbuch. d. prak. Chir., Stuttgart, 1913, 4th ed., p. 117.

CYLINDRICAL DILATION OF THE COMMON CAROTID ARTERY FOLLOWING PARTIAL OCCLUSION OF THE INNOMINATE AND LIGATION OF THE SUBCLAVIAN[1]

The following unique observation confirms, on the human subject, the discovery made on dogs that a partially occluding band may cause a distal dilation of the artery,[2] and probably sheds light on the pathogenesis of the aneurisms of the subclavian which occur in cases of cervical rib. It may, furthermore, help to explain the dilatation of the arterial trunk, which I find from the perusal of about 400 reports has quite frequently been noted on the cardiac side of arterio-venous fistulae,[3] and which, in our own clinical and experimental cases, has occurred invariably; and conceivably it may eventually lead to the discovery of a law or laws governing the preservation of the integrity of the arterial wall and thus to the better interpretation of certain pathological phenomena of the vascular system.

Mrs. B., aged fifty years (Surg. No. 18357), was admitted to The Johns Hopkins Hospital October 17, 1905, suffering from a large aneurism of the right subclavian artery (see Plate XXXIX, 1).

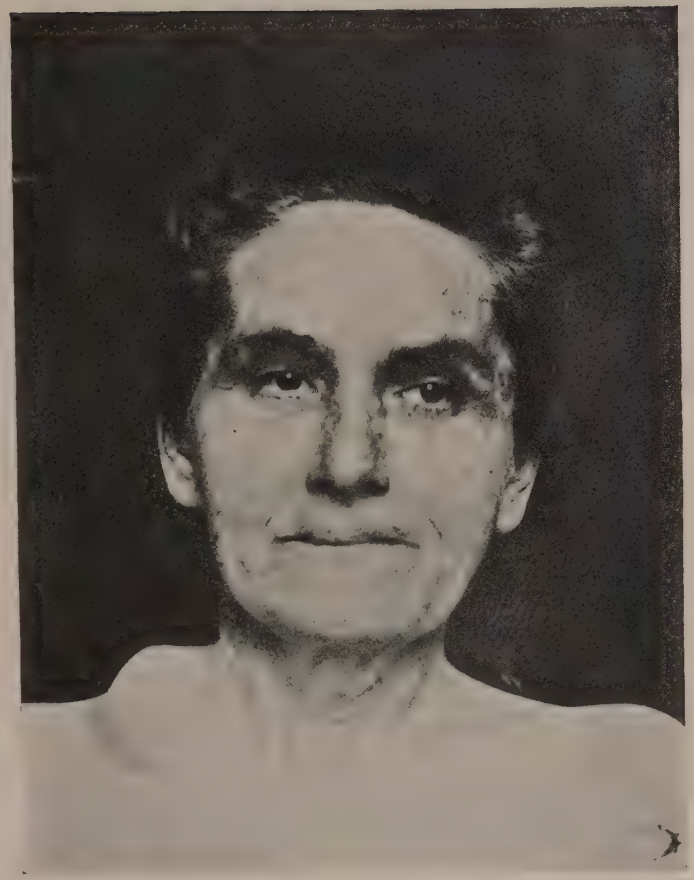
November 17th, First Operation.—An aluminum band was applied to the innominate artery and tightened until the pulse in the aneurism was almost completely obliterated.

January 12, 1906, Second Operation.—The constriction of the innominate artery having, apparently, uninfluenced the aneurism an attempt was made to excise it. Enucleation, almost accomplished, was not completed because the sac could not be freed from the subclavian vein. Hence, the subclavian artery was ligated in its first portion close to its origin from the innominate

[1] Presented before the American Surgical Association, Cincinnati, June 6-8, 1918. Tr. Am. Surg. Ass., Phila., 1918, xxxvi, 501-518. (Reprinted.)
Also: Surg. Gyn. & Obst., Chicago, 1918, xxvii, 547-554. (Reprinted.)

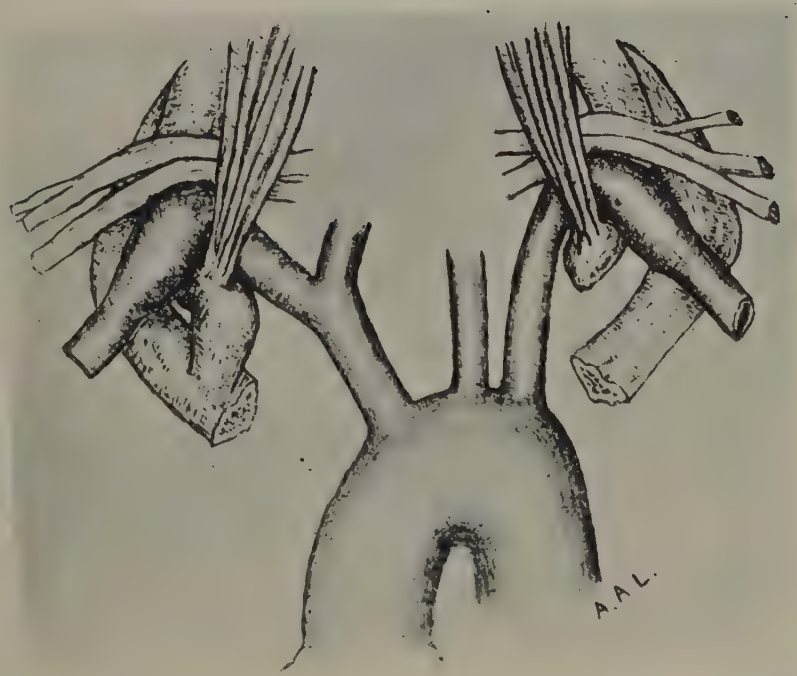
[2] Halsted and Reid: An Experimental Study of Circumscribed Dilation of an Artery Immediately Distal to a Partially Occluding Band, and its Bearing on the Dilation of the Subclavian Artery Observed in Certain Cases of Cervical Rib. *Ibid.:* Partial Occlusion of the Aorta with the Metallic Band. Observations on Blood Pressures and Changes in the Arterial Walls. Jour Exp. Med., 1916, xxiv, 271, 287.

[3] William Hunter was first to describe an arterio-venous aneurism. He noted in his first and second Cases what so many surgeons have since overlooked, that the artery concerned becomes dilated proximal to the fistula. *Ibid.:* The History of an Aneurism of the Aorta, with Some Remarks on Aneurisms in General. Medical Observations and Inquiries, 1757, i, 323. *Ibid.:* Further Observations upon a Particular Species of Aneurism, Medical Observations and Inquiries, 1762, ii, 390.



1.—Mrs. B.——, November, 1905. Aneurism of the right subclavian artery.

2.—Mrs. B.——, February, 1918. Twelve and a half years after the application of a partially occluding band to the innominate artery and ligation of the right subclavian artery in its first and third portions. Distal to the band the innominate and carotid arteries are dilated. (Outlined by Dr. W. F. M. Sowers.)



1.—Dilation of the right and left subclavian arteries above the cervical ribs and distal to the site of constriction. (Reproduced by the courtesy of Dr. Arthur A. Law and the editor of the Journal-Lancet.)

2.—"Dilation of the axillary artery and vein proximal to a fistula of thirty years' duration. *S.A.M.*, scalenus anticus muscle; *I.M.A.*, internal mammary artery; *B.P.*, brachial plexus; *A.A.*, axillary artery; *A.V.*, axillary vein; *C.V.*, cephalic vein; *T.A.A.*, thoracico-acromial artery." (Reproduced by the courtesy of Sir William Osler and the editor of the London Lancet.)

and in its third portion on the confines of the axillary artery. Both of the ligatures were tied quite close to the aneurism, which had been so thoroughly freed in the course of the dissection as to make their application easy. Pulsation in the aneurism was completely interrupted for a few minutes only. Temporary occlusion of the right common carotid, which was normal in size, seemed to be without influence either before the subclavian was ligated or after the return of pulsation in the sac subsequent to the ligations. A light plaster-of-Paris dressing, completely concealing the feebly pulsating aneurism, was applied.

Ten days later (January 22, 1906) the cast was removed and the aneurism, to my surprise, found to be pulseless, although little if any smaller.

December 14th.—Patient returned for observation. Dr. Sowers noted a slight systolic bruit distal to the band and a " rumbling systolic bruit " on the proximal side of the constriction.

April 2, 1909.—There is a circumscribed, hard, non-pulsating nodule, about the size of a Madeira nut, at the site of the late aneurism. Pulse in the radial artery is palpable. No disturbance of sensation or motion is complained of. Patient states that her health is excellent and that she has not been annoyed by the loss of the clavicle and part of the manubrium. The right common carotid is dilated to about twice the normal size throughout its entire length. There is, however, no suggestion of a circumscribed, aneurism-like dilatation. The innominate artery, proximal to the band, is not enlarged.

March 31, 1911.—Note by Dr. Heuer: The carotid pulsates strongly just above the level of the clavicle. This vessel is dilated, having a diameter of about 2.5 cm. There is still a little mass, non-pulsating, at the site of the former aneurism.[4] No pulse can be felt in the right radial or right brachial. The right hand is a little colder than the left, but there is no swelling of the arm, forearm or hand.

March 16, 1917.—Note by Dr. Sprunt: There is marked inequality of the radial pulses, the right being the smaller.

February 15, 1918.—Note by Dr. Reid: Patient has come from her home in Washington for demonstration at Dr. Halsted's clinic. She states that she is perfectly well and has no abnormal sensations. Pressure over and just above the band compels a cough. The right hand seems as strong as the left and the sensation of a cold right hand, of which she was formally conscious, has altogether vanished. The last trace of the old aneurismal sac is gone. The band is definitely though indistinctly palpable. There is a marked dilation of the right common carotid from the band to the bifurcation (see Plate XXXIX, 2 and Fig. 48). Below the band one can trace the innominate artery for a short distance; it is certainly not dilated in the proximal portion.

The dilation of the carotid is somewhat fusiform at its central end. The greatest width of the artery (2.8 cm.) is about 1 cm. above the upper edge of the band. From this point (Fig. 48, *b*) the diameter diminishes rather rapidly, losing 1 cm. in an equal stretch of the vessel, which then maintains

[4] Thus five years and three months after the cure of the aneurism a trace of the tumor remained.

an almost cylindrical but slightly tapering form to the bifurcation (see Fig. 48). The innominate, which at the operation was considerably constricted by the metal tube, is now smaller below than above it—smaller probably than normal. A distinct bruit, audible along the whole course of the right carotid, is loudest just above the band. It is not heard below it, over the innominate. Pressure here on the innominate obliterates the pulse in the carotid. The blood is surely coursing through the aluminum tube. The heart is not demonstrably enlarged nor is the aorta. The right radial pulse is feeble, but easily countable. Its systolic pressure is 80+; the diastolic pressure cannot be accurately determined. In the left arm the blood pressure is 180/90.

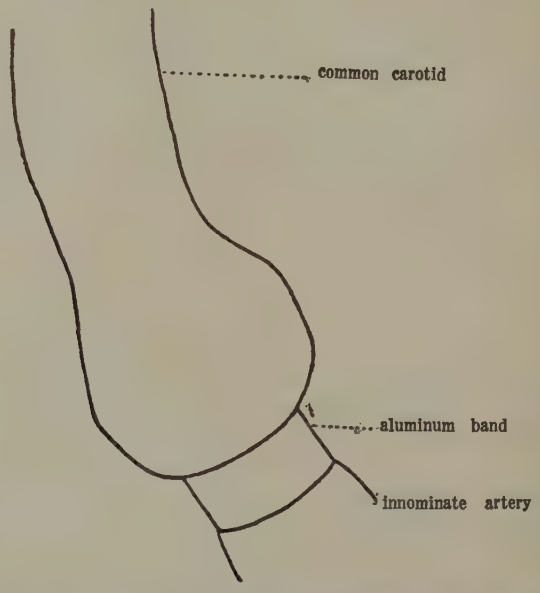


Fig. 48.—Mrs. B.——, February 15, 1918. Diagram, actual size, made from Dr. Reid's measurements.

Thus on the human subject we have now a striking confirmation of the observations which Dr. Reid and I have made upon the aorta of dogs. Four or five times in the past twelve and a half years this most obliging of patients has journeyed to Baltimore in response to my letters, and nine years ago I made a note of the remarkable manifestation—a cylindrical dilation of the common carotid throughout its entire length. But not until this year did the explanation of the phenomenon occur to me, although for many years I have pondered the subject of the dilations distal to the point of constriction in cases of cervical rib, and four years ago observed for the first time a dilation of the aorta, distal to a partially occluding band, in the dog (see Figs. 34-37). How true it is for some at least that facts may almost strike us in the face and still pass unobserved.

In the analysis of 525 clinical cases of cervical rib I found 106 in which the subclavian artery had been compressed, and that in 27 of these aneurism or dilatation of this vessel distal to the site of constriction had been noted. Interesting illustrations appear in the papers of Keen[5] and Law[6] (see Fig. 49 and Plate XL, 1).

Dilatation of the Heart in Cases of Arterio-Venous Fistula

A particularly interesting result of our clinical and experimental studies of arterio-venous fistula is the discovery that enlargement of the heart probably occurs after a time, as a rule, in the major cases. My attention was forcibly called to this complication some ten years ago by a case of fistula

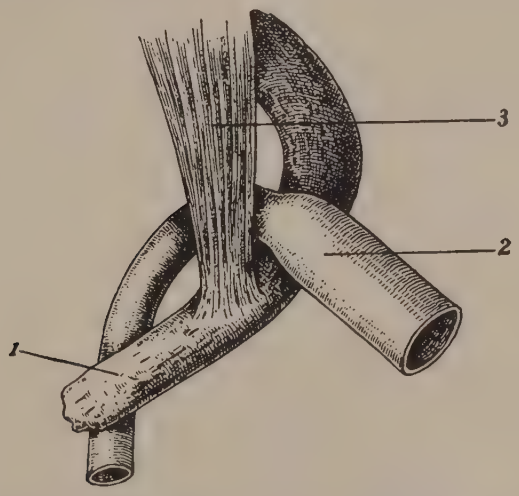


Fig. 49.—1, cervical rib; 2, subclavian artery dilated distal to the site of constriction; 3, scalenus anticus muscle. (Reproduced by the courtesy of Dr. W. W. Keen and the editor of the American Journal of the Medical Sciences.)

of the femoral vessels which I saw in consultation with Dr. James F. Mitchell, of Washington, and upon which together we operated in the Providence Hospital. The phenomenal enlargement of the heart must, I thought, have been due to the fistula, and have been secondary to the enormous dilation of the aorta and vena cava. Since then we have more carefully noted the condition of the heart in our cases of arterio-venous aneurism and have, I believe, quite invariably found it enlarged—strikingly so in several instances. If the assumption is correct that the heart dilates in consequence of the fistula it is important that the fact should be brought to the attention

[5] The symptomatology, diagnosis and surgical treatment of cervical ribs, Am. Jour. Med. Sc., Philadelphia, 1907, cxxxiii, 173.

[6] The surgical aspect of cervical ribs, Journal-Lancet, Minneapolis, 1914, xxxiv, 330.

not only of surgeons but also of pathologists and internists who apparently have altogether overlooked it. Dr. Mont Reid has in preparation a report upon his experimental and clinical work in arterio-venous fistula in which he will offer convincing experimental proof of our view that the fistula may in its consequences profoundly affect the heart as well as the veins and arteries; and Dr. Curle L. Callander is making a careful study of all the reported cases of arterio-venous fistula in order to weigh the clinical evidence bearing on this subject which these records may furnish.

When a causative relationship between arterio-venous fistula and dilation hypertrophy of the heart shall have become convincingly established we may find that some unexplained dilations of the heart are referable to hitherto undetected changes in the walls and lumen of the blood vessels. That a very considerable dilation of blood vessels may be overlooked at autopsy our experiments in the partial occlusion of arteries has convinced us. It is impossible to estimate the amount of dilation of either an artery or a vein in its collapsed state. Arteries as well as veins which, when empty, give no indication of increase in calibre may, on injection, prove to have been markedly dilated. All surgeons know how true this is of veins. A vein to which, when full of blood, von Langenbeck in deference would, as he said, remove his hat, might, when empty, be hardly recognizable in the course of an operation.

There may be more or less circumscribed aneurismal expansions in the continuity of the otherwise cylindrically dilated, proximal arterial trunks. I have observed this in two or three of my patients. One such expansion is shown proximal to the fistula in the postmortem specimen of a famous case reported by Osler[7] (see Fig. 50)and another in Eisenbrey's[8] particularly interesting illustration (see Plate XL, 2). I am quite sure that in Osler's case there was a much greater dilation of the artery above the aneurism and between the aneurism and the fistula than the drawing indicates, for, as I have said, one cannot judge of the size of the lumen from the appearance of the empty vessel. It would interest Sir William to compare the very similar drawings illustrative of the two cases, his own and Eisenbrey's, as the latter's proves that the fistula may be a considerable distance below the point at which the artery has become conspicuously dilated and thus offers strong presumptive evidence that the reason why the specimen of the former lacks the evidence of the fistula is because it was too greatly curtailed by the

[7] Case of arterio-venous aneurism of the axillary artery and vein of fourteen years' duration. Ann. Surg., Philadelphia, 1893, xvii, 37. *Ibid.:* an arterio-venous aneurism of the axillary vessels of thirty years' duration. Lancet, London, 1913, ii, 1248. Makins, G. H.: surgical experiences in South Africa, 2d ed., 1913, p. 148.

[8] Arterio-venous aneurism of the superficial femoral vessels. Jour. Am. Med. Assn., Chicago, 1913, lxi, 2155.

pathologist. The pathologist, by the way, should not be too harshly censured for missing the key to the situation, for if, perchance, he had been aware that the artery should be dilated central to the fistula he could hardly by any possibility have known that it might retain approximately its normal calibre for a distance so far from the arterio-venous communication.

Thanks to the assistance of highly competent secretaries, I have abstracts of 380 cases of arterio-venous fistula. These have been studied with special reference to occasional observations on the dilation of the artery. In 52

FIG. 50.—Dilation of the external and common iliac arteries and veins proximal to a fistula of the superficial femoral vessels. Reproduced by the courtesy of Dr. A. B. Eisenbrey and of the editor of the Journal of the American Medical Association.)

instances proximal dilation of the arterial trunk has been noted. In 11, dilation was mentioned, but whether proximal or distal or both is not specified. I am quite sure that in almost every instance in which the fistula had existed two months or more proximal dilation of the artery would have been ascertainable if looked for. The size of the involved artery both above and below the fistula should always be compared with that of its fellow. The dilation, as a rule, extends probably to the heart, which also in my

opinion is likely, as I have said, to be dilated. The size of the narrowed artery below the fistula may be difficult to determine without dissection. In view of the observations of Luigi Porta, Dr. Reid and myself, it would be well also to bear in mind the possibility of a dilation of any great artery distal to the site of ligation, and the probability of such dilation if perchance the lumen were in some measure to be reestablished. As the dilation distal to a totally occluding ligature has been observed only in dogs and only in the aorta and its triad of branches further experimentation is necessary for the determination of the part played by other possible factors, for example, by the anastomotic circulation and by the proximity of the nearest branches—by the length of the dead arterial pocket, in other words.

In a previous paper[9] I made the statement that dilation had not been observed below a totally occluding band. Since then, however, a slight degree of dilation, distal to the completely obturated vessel, has taken place in three instances. A dilation of this ventricle-like portion of the aorta between the band and the trifurcation might be expected even in case of complete occlusion, for the anastomosis is very free in this situation and the dead pocket is usually, and perhaps always, too short to become obliterated. Lumbar branches may be given off just below, as they are just above the band.

In two instances I have made the following observation in testing, during the life of the animal, for the patency of the aorta under the band. Pressure with the finger immediately above the band shut off the pulse in what we term the ventricle; whereas, pressure with the back of the scalpel blade, made as close to the band as possible, did not. In these cases there was a patent lumbar artery so close to the proximal edge of the band that pressure by the finger obliterated it, whereas the knife blade which could be brought to bear on the aortic wall between this little artery and the upper edge of the band did not interrupt the flow in this important anastomotic branch. The contribution of this little artery to the anastomotic bloodstream was sufficient to convert an inpalpable into a palpable pulse. A palpable pulse in the ventricle below the band is so invariable, whether the aorta has been completely occluded or not, that the patency of the artery under the band cannot be definitely determined during the life of the animal unless temporary occlusion of it between the band and the nearest lumbar artery obliterates or decidedly influences the pulse in the ventricle. If pressure above the band does not affect the pulse just below it we may conclude that obturation is complete.

Fortunately it occurred to me a few days ago to restudy, with reference to the possibility of finding depicted a dilation of an artery below a liga-

[9] Halsted and Reid: *Loc. cit.*

1. — The aorta of a dog eight months after ligation. Aorta dilated distal to the site of the ligation. (Luigi Porta, *loc. cit.*)

2.—The aorta of a dog fifteen months after ligation. Note the distal dilatation and the anastomotic circulation. (Luigi Porta, *loc. cit.*)

ture, the sketches of surgeons who in bygone years had experimentally ligated the blood vessels of animals. I was delightfully surprised to find, in the beautifully illustrated volume of Luigi Porta,[10] published in 1845, two drawings which portray a pronounced dilatation of the aorta and its ventricle immediately below the site of ligation (see Plate XLI, 1 and 2). The ligatures in the two dogs had been applied eight and fifteen months before the death of the animals. There is a great bundle of dilated vessels—the vasa vasis—bridging the gap between the retracted ends of the dilated aorta (Plate XLI, 2).

Thus three-quarters of a century ago this great, perhaps the greatest, surgeon of Italy furnished irrefutable proof of a remarkable phenomenon which must eventually have interest for the physiologist, the pathologist and the surgeon. Luigi Porta describes the drawing but makes no further comment upon the dilation.

Before the introduction of antiseptic surgery by Lister, thrombosis quite invariably followed ligation of an artery, and it was to the organization of the thrombus that the surgeon looked for the prevention of secondary haemorrhage and for the preservation of the life of the patient. If thrombi formed in these two cases of Porta they must have been eventually absorbed, for the distribution of the dilated vasa vasis proves that the aortic free ends were patulous, and we have further proof of this in the dilation of the aortic ventricle immediately below the site of the ligation.

In the course of my experiments in partial occlusion of the arteries I have often studied the illustrations, carefully I thought, in Luigi Porta's work, but not until I scanned them with the particular object in view did I discover the dilatations so strikingly manifest. I wonder if anyone has ever commented upon or been interested in these two observations of Porta.

The following summary is quoted from a paper read at the annual meeting of the National Academy of Sciences in April of this year.

Summary

1. A partially occluded artery (abdominal aorta, innominate, carotid, subclavian) may dilate distal to the site of constriction.

2. The dilation is circumscribed and has been greatest when the lumen of the artery (the aorta) was reduced to about one-third or perhaps one-fourth of its original size.

3. When the obturation has been slight in amount dilation has not been observed; of 7 cases of complete obstruction there has been a very moderate degree of dilation in 3 and none in 4.

[10] Delle alterazioni patologiche delle arterie per la legatura e la torsione. Milano, 1845, pp. 350, Plate V, Figs. 3 and 5.

4. Complete or partial occlusion of the thoracic aorta may be followed by dilation central to the point of constriction.

5. Dilation or aneurism of the subclavian artery has been observed twenty-seven or more times in cases of cervical rib.

6. The dilation of the subclavian in these cases is circumscribed, is distal to the point of constriction and strikingly resembles the dilation which we have produced experimentally.

7. The dilation of the artery proximal to an arteriovenous fistula and distal to a partially occluding band may prove to be referable to the same cause.

8. When the lumen of the aorta is considerably constricted the systolic pressure may be permanently so lowered and the diastolic pressure so increased that the pulse pressure may be diminished by one-half.

9. The experimentally produced dilations and the aneurisms of the subclavian artery in cases of cervical rib are probably not due to vasomotor paralysis, trauma or sudden variations in blood pressure.

10. The abnormal, whirlpool-like play of the blood in the relatively dead pocket just below the site of the constriction and the lowered pulse pressure may be the chief factors concerned in the production of the dilatation.

11. Bands, rolled ever so tightly, do not rupture the intima.

12. Intimal surfaces brought, however gently, in contact by bands or ligatures do not, in our experience, unite, for the force necessary to occlude the artery is sufficient to cause necrosis of the arterial wall.

13. The death of the arterial wall having been brought about by the pressure of the band, a gradual substitution of the necrotic tissue takes place, the new vessels penetrating it from both ends. It is, I believe, in this manner that an artery becomes occluded, and it is thus that a fibrous cord forms within the constricting band.

DILATION OF THE GREAT ARTERIES DISTAL TO PARTIALLY OCCLUDING BANDS[1]

The incentive to the work was primarily the desire to cure aneurisms of the abdominal aorta and common iliac arteries.

The method usually employed for the cure of aneurism is the simplest, viz., the ligation of the affected artery proximal and as close as feasible to the aneurism. The aorta has been ligated 25 or more times in man, and always with fatal result. Death has been due to haemorrhage or overtaxed heart. Neither gangrene nor paraphlegia has ever resulted from ligation of the aorta in man. We found, in dogs, as was to have been expected, that fine, completely occluding, ligatures (sizes C or E sewing silk) applied to the thoracic aorta just below the arch would cut through in about two days, and invariably with promptly fatal haemorrhage; whereas coarse ligatures usually made their way through the aortic wall very slowly and without leakage of blood. A connective tissue diaphragm often forms in the wake of these broader threads and the lumen of the vessel may be more or less completely reestablished.

It occurred to me after much experimentation that occlusion of the aorta to a degree not sufficient fatally to overburden the human heart might effect the cure of an aortic aneurism. Knotted ligatures we found to be unsuitable, for a desired degree of constriction or obliteration could not be accurately obtained nor could the crushing of the arterial wall be invariably avoided. Tapes of various materials were tested—of cotton, of chromicized intestinal submucosa, of elastic tissue obtained from the aorta, of aponeurotic white fibrous tissue. These were applied in spiral or cuff form. Best suited to the purpose were bands of metal, of aluminum, accurately rolled in cylindrical form by a little instrument of this kind (exhibit). In the use of these metal bands it was impossible to crush the arterial wall, and the desired amount of obturation could be obtained with precision, and also maintained.

The infolded and snugly opposed intimal surfaces under the compressing band have in no instance adhered to each other, and for the reason that the pressure necessary to produce even a very slight reduction in the lumen of the vessel has, in my experience, invariably caused atrophy of its wall. When

[1] Presented before the National Academy of Sciences, Washington, D. C., April 2, 1918.

Proc. Nat. Acad. Sc., Balt., 1918, iv, 204-210. (Reprinted.)

the occlusion is complete the necrotic arterial wall included in the metal band becomes replaced by a solid cylindrical cord of fibrous tissue, the substitution taking place from the ends.

An interesting incidental observation which we have made in the course of our experiments with the metal band is this; that a dilation of the artery occurs just below a band when the degree of constriction is of the proper amount. This observation apparently explains in a measure the occurrence of aneurisms of the subclavian artery distal to a cervical rib. Analyzing 525 clinical cases of cervical rib, we found 106 in which the subclavian artery had been compressed, and that in 21 of these aneurism or dilation of this vessel distal to the site of constriction had been noted.

As to the cause of these aneurisms, five of which have come to the knowledge of the collators, there has been varied conjecture. Commentators are, however, agreed that the occurrence of the dilation would have been less incomprehensible to them had it manifested itself on the proximal instead of the distal side of the compression. Attempts have been made to explain the phenomenon, and the following suggestions offered as to its possible cause:

(1) Weakening of the wall of the subclavian artery from erosion by the rib.

(2) Variable or intermittent pulse pressure occasioned by the normal excursions of the arm.

(3) Vasomotor and vasa vasorum disturbances leading to modified nutritional activities in the wall of the artery.

In casting about for an explanation of these aneurisms there constantly obtruded itself the picture of the dilated arterial trunks which, I find from the study of about 400 cases, has occasionally been noted on the cardiac side of arterio-venous fistulae. In our own clinical and experimental cases, dilation of the artery proximal to the fistula has occurred invariably. For this remarkable manifestation, likewise, no satisfactory cause has been assigned. There might, I thought, be a common cause for both—for the dilation of the subclavian artery distal to the cervical rib, and for the dilation, central to the arterio-venous fistula, of the artery concerned in its formation. Hence, for a number of years, in the course of various experiments in partial occlusion of the arteries, I had somewhat in view the possibility of the production, beyond the point of constriction, of a dilation of the artery, analogous to the dilations which have been observed in cases of cervical rib.

Four years ago when after many trials I had altogether despaired of having the hope realized, I was startled, on examining the abdomen of a dog whose aorta had been constricted for about six months to see that each of

the branches of trifurcation had become dilated almost to the size of the main aortic trunk.

With this observation as incentive, Dr. Mont Reid and I, the following winter, constricted the abdominal aorta just above its trifurcation, in many dogs and at intervals explored and reexplored the abdominal cavities, but with negative result. Finally, on investigating the abdomen of the last dog we found the hoped-for dilation. The degree of obturation of the aorta was accurately determined on sacrificing the animal, and the following year the experiments were more advantageously repeated because of the data obtained from this case. Now, that we have apparently determined the relative amount of constriction required to give the most pronounced results we are able in almost every instance to produce the dilation.

As regards the cause of the dilation produced experimentally we may, I think, conclude that it is not to be found in any of the three factors which have been proposed as responsible for the dilation observed in cases of cervical rib, viz., (1) vasomotor paralysis, (2) trauma and (3) variable blood pressure.

Ad. 1. *Vasomotor Paralysis.* (a) The vasomotor nerves and the vasa vasorum are destroyed by the moderately constricting and totally occluding bands quite as surely as by those which, occluding almost totally, have produced the greatest amount of dilation. (b) Only a portion of the circumference of the subclavian artery is exposed to the pressure of the cervical rib and the scalenus anticus muscle and hence only a fraction of the vasomotor nerves or vasa vasorum could be pressed upon.

Ad. 2. *Trauma.* (a) The dilation is usually fusiform and distal to the rib. (b) Trauma is excluded as a factor in the experimental dilations.

Ad. 3. *Variable Blood Pressure.* (a) Patients suffering from the pressure-pain of cervical rib rarely make wide excursion movements of the arm. (b) The degree of occlusion is constant in the experimentally constricted vessel.

When an arterial trunk is ligated it becomes occluded to the first proximal and first distal branches and ultimately reduced to a fibrous strand.

From observations which we have made on man and dogs I am quite sure that there may be a remarkable fall in blood pressure in what I have termed "the dead arterial pocket," while there is still little if any sign of diminution in the calibre of this portion of the vessel. For example, the right common carotid was ligated by the writer in a case of aneurism of the external carotid. About three months later, in the course of an operation for the excision of the uncured aneurism, the internal carotid, dead-pocketed between the circle of Willis and the carotid ventricle, was freely exposed for a considerable distance. It had lost its cylindrical form, being flat and

tape-like, and, although evidently possessing a considerable lumen, seemed to be empty. When incised, a few drops of blood oozed without pulse from the little cut. The artery was then resected. Its wall was thickened on one side but the lumen was still perhaps three times that of a radial artery. Similar observations I have made twice on the external iliac of the dog after occlusion of this vessel at its origin from the aorta. In the dead pocket between the aorta and the origin of the circumflex iliac and common trunk of the epigastric and obturator arteries the blood pressure must have been almost nil, because from a little slit in the apparently normal arterial wall of the relatively empty external iliac artery the blood escaped very slowly in a tiny, almost pulseless jet about 1 cm. high; whereas, from the femoral artery, below the profunda, the blood spurted normally from a similar knife-prick.

Hence in an artery doomed to obliteration, it would seem that the blood pressure may be lowered before the occlusion process sets in—the lowered pressure being, perhaps, the immediate factor leading to the obliteration.

Can these observations have any bearing upon the explanation of the dilation of the aorta above its trifurcation and of its triad branches in the dog after partial occlusion; of the dilation of the carotid in the human subject which I have observed in one case after partial occlusion of the innominate combined with ligature of the first and third portions of the right subclavian; and of the aneurism of the third portion of the subclavian in cases of cervical rib?

In 1906 Dr. Richardson and I made the observation that after partial occlusion of the thoracic aorta the maximum pressure may be permanently lowered and the minimum pressure permanently increased distal to the constricting band; and in recent experiments Dr. Reid and I have observed that after constriction of the lower abdominal aorta the diastolic pressure may be so increased and the systolic pressure so lowered as to reduce the pulse pressure by nearly one half. The blood stream in this case, passing with greater velocity and less pressure through the band prevents the obliteration of the artery to the nearest branch, the pocket being not a dead one as it is in the case of total obliteration. The blood in this pocket beyond the constriction streams, presumably, in whirlpools, somewhat as in the vein and, also, as in the artery in arterio-venous fistula; the thrill, not palpable at first if the occlusion has been nearly complete, later may be perceived with the finger; and the bruit, always audible with the stethoscope, becomes louder as the peripheral arterial resistance increases.

To these factors, then—to the abnormal play of the blood in the relatively, as distinguished from the absolutely dead pocket and to the absence of

normal pulse pressure, essential probably to the maintenance of the integrity of the arterial wall, we may have to look for the solution of our problem.

We have completely occluded the aorta just above the trifurcation only in dogs. Usually there has been no distal dilation, and in a previous paper I made the statement that dilation had not been observed below a totally occluding band. Since then, however, a slight degree of dilation, distal to the completely obturated vessel, has taken place in three instances. A dilation of this ventricle-like portion of the aorta between the band and the trifurcation might be expected even in case of complete occlusion, for the anastomosis is very free in this situation and the dead pocket is usually, and perhaps always too short to become obliterated. Lumbar branches may be given off just below, as they are just above the band.

In two instances I have made the following observation in testing, during the life of the animal, for the patency of the aorta under the band. Pressure with the finger immediately above the band shut off the pulse in what we term the ventricle; whereas, pressure with the back of the scalpel blade, made as close to the band as possible, did not. In these cases there was a patent lumbar artery so close to the proximal edge of the band that pressure by the finger obliterated it, whereas, the knife blade which could be brought to bear on the aortic wall between this little artery and the upper edge of the band did not interrupt the flow in this important anastomotic branch. The contribution of this little artery to the anastomotic bloodstream was sufficient to convert an impalpable into a palpable pulse. A palpable pulse in the ventricle below the band is so invariable, whether the aorta has been completely occluded or not, that the patency of the artery under the band cannot be definitely determined during the life of the animal unless temporary occlusion of it between the band and the nearest lumbar artery obliterates or decidedly influences the pulse in the ventricle. If pressure above the band does not affect the pulse just below it we may conclude that obturation is complete.

Fortunately it occurred to me a few days ago to restudy, with reference to the possibility of finding depicted a dilation of an artery below a ligature, the sketches of surgeons who in bygone years had experimentally ligated the blood vessels of animals. I was delightfully surprised to find, in the beautifully illustrated volume of Luigi Porta [2] published in 1845 two drawings which portrayed a pronounced dilation of the aorta and its ventricle immediately below the site of ligation. The ligatures in the two dogs had been applied eight and fifteen months before the death of the animals. There

[2] Luigi Porta. Delle alterazioni patologiche delle arterie per la legatura e la torsione. Milano, 1845, pp. 350, 351, Plate V, Figs. 3 and 5.

is a great bundle of dilated vessels—the vasa vasis—bridging the gap between the retracted ends of the divided aorta.

Thus three-quarters of a century ago this great, perhaps the greatest surgeon of Italy, furnished irrefutable proof of a remarkable phenomenon which must eventually have interest for the physiologist, the pathologist and the surgeon. Luigi Porta describes the drawing but makes no further comment upon the dilation.

Before the introduction of antiseptic surgery by Lister, thrombosis quite invariably followed ligation of an artery, and it was to the organization of the thrombus that the surgeon looked for the prevention of secondary haemorrhage and for the preservation of the life of the patient. If thrombi formed in these two cases of Porta they must have been eventually absorbed, for the distribution of the dilated vasa vasis proves that the aortic free ends were patulous, and we have further proof of this in the dilation of the aortic ventricle just below the site of the ligation.

In the course of my experiments in partial occlusion of the arteries I have often studied the illustration, carefully I thought, in Luigi Porta's work, but not until I scanned them with the particular object in view did I discover the dilations so strikingly manifest. I wonder if anyone has ever commented upon or been interested in these two observations of Porta.

In the human subject I have in one instance observed a remarkable dilation of an artery distal to a partially occluding band. In this case an aluminum band was applied to the innominate artery for the cure of a subclavian aneurism. A few weeks later, the aneurism being uninfluenced by this procedure, the subclavian artery was ligated both proximal and distal to the sac, and a cure effected. Three years later a quite cylindrical dilation of the right common carotid was observed; and now, twelve years after the application of the band, the common carotid artery is strikingly dilated throughout its entire length. The band on the innominate can be palpated; the blood is coursing through it, and distal to the band is a distinct bruit (exhibit).

Summary

1. A partially occluded artery (abdominal aorta, innominate, carotid, subclavian) may dilate distal to the site of constriction.

2. The dilation is circumscribed and has been greatest when the lumen of the artery (the aorta) was reduced to one-third or perhaps one-fourth of its original size.

3. When the obturation has been slight in amount dilation has not been observed; of 7 cases of complete obstruction there was a very moderate degree of dilation in 3, and none in 4.

4. Complete or partial occlusion of the thoracic aorta may be followed by dilation central to the point of constriction.

5. Dilation or aneurism of the subclavian artery has been observed twenty-seven or more times in cases of cervical rib.

6. The dilation of the subclavian is circumscribed, is distal to the point of constriction, and strikingly resembles the dilation which we have produced experimentally.

7. The dilation of the artery proximal to an arterio-venous fistula and distal to a partially occluding band may prove to be referable to the same cause.

8. When the lumen of the aorta is considerably constricted the systolic pressure may be permanently so lowered and the diastolic pressure so increased that the pulse pressure may be diminished by one-half.

9. The experimentally produced dilations and the aneurisms of the subclavian artery in cases of cervical rib are probably not due to vasomotor paralysis, trauma, or sudden variations in blood pressure.

10. The abnormal, whirlpool-like play of the blood in the relatively dead pocket just below the site of the constriction, and the lowered pulse pressure may be the chief factors concerned in the production of the dilation.

11. Bands, rolled ever so tightly, do not rupture the intima.

12. Intimal surfaces, brought, however gently, in contact by bands or ligatures do not, in our experience, unite by first intention, for the force necessary to occlude the artery is sufficient to cause necrosis of the arterial wall.

13. The death of the arterial wall having been brought about by the pressure of the band, a gradual substitution of the necrotic tissue takes place, the new vessels penetrating it from both ends. It is, I believe, in this manner that an artery becomes occluded, and it is thus that a fibrous cord forms within the constricting band.

CONGENITAL ARTERIO-VENOUS AND LYMPHATICO-VENOUS FISTULAE. UNIQUE CLINICAL AND EXPERIMENTAL OBSERVATIONS[1]

A. *Advance of a Proximal Arterial Dilatation Conformably to the Transposition, after Operation, of the Fistula.*—Thanks to the assistance of highly competent secretaries I have abstracts of about 400 cases of arterio-venous fistula. These have been studied with especial reference to occasional observations on the dilatation of the arteries. In 52 instances proximal dilatation of the arterial trunk has been noted. I am quite sure that in almost every instance in which the fistula had existed for two or more months proximal dilatation of the artery would have been demonstrable if looked for.

Congenital arterio-venous fistula is rare, particularly so when unassociated with naevus. We have been able to find reports of only two cases without and six with naevus. Of the former neither was cured, unless we except the case of von Eiselsberg, in which an attempt to cure a fistula between the popliteal artery and vein was followed by gangrene, necessitating amputation of the thigh.

The following case, unique in several particulars, is reported to record the arterial changes observed at two operations, the second performed $6\frac{1}{2}$ years after the first.

The patient, a girl aet. eleven years, was operated upon by the author, November 15, 1911, for a congenital arterio-venous fistula below the angle of the jaw on the right side. After the removal of a tumor-like mass of enormously dilated veins it was found that the fistula was between one of these and the external carotid artery near the bifurcation or ventricle of the common carotid. Fortunately a careful note was made at the operation of a very small, anomalous, ascending branch given off from the external

[1] Presented at the Autumn Meeting of the National Academy of Sciences at The Johns Hopkins University, Baltimore, November 8, 1918.

Also presented at the American Surgical Association, Atlantic City, N. J., June 16-18, 1919.

Proc. Nat. Acad. Sc., Balt., 1919, v, 76-79. (Reprinted.)

Also: Tr. Am. Surg. Ass., Phila., 1919, xxxvii, 262. (Reprinted.)

Also: Contrib. Med. & Biol. Research . . . . Sir W. Osler, N. Y., 1919, i, 560-567. (Reprinted.)

carotid just proximal to the fistula (*vid.* Fig. 51). There was great dilatation of the common carotid and of the external carotid arteries proximal to the fistula, whereas the internal carotid was surprisingly small. The vessels concerned in the fistula formation were excised, the aberrant artery happily being spared. The child was relieved of very distressing symptoms

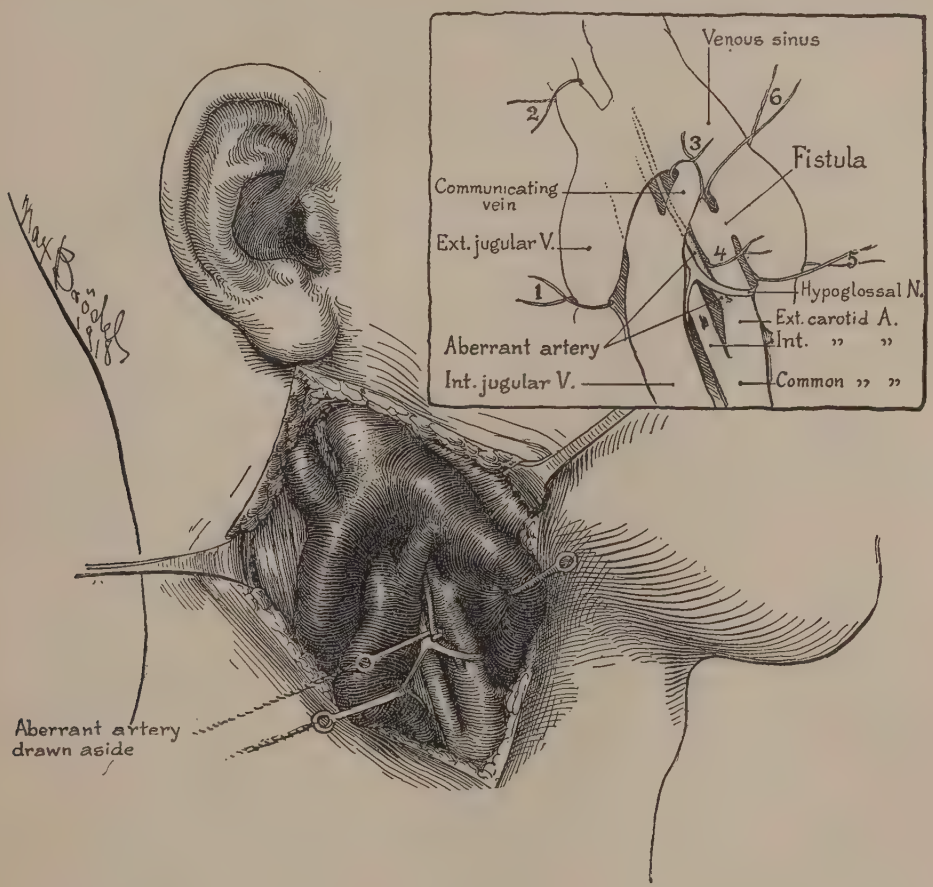


FIG. 51.—Congenital fistula between the external carotid artery and a large vein. Appearances at the first operation. Dilatation of the common and external carotid arteries central to the fistula, and of the venous plexus. The internal carotid is abnormally small. There is a tiny, aberrant branch of the external carotid.

by the operation, but a few weeks later signs of a second, smaller fistula developed at a distal point, just below and in front of the ear. A second operation, proposed frequently, was not acceded to until last spring, 6½ years after the first. At this operation, performed by my assistant, Dr. Mont Reid, in my presence, remarkably interesting observations were made. The tiny aberrant artery had become dilated almost to the size of a goose quill,

and the internal carotid, which at the first operation was strikingly small, was, we estimated, as large as normal (*vid.* Fig. 52).

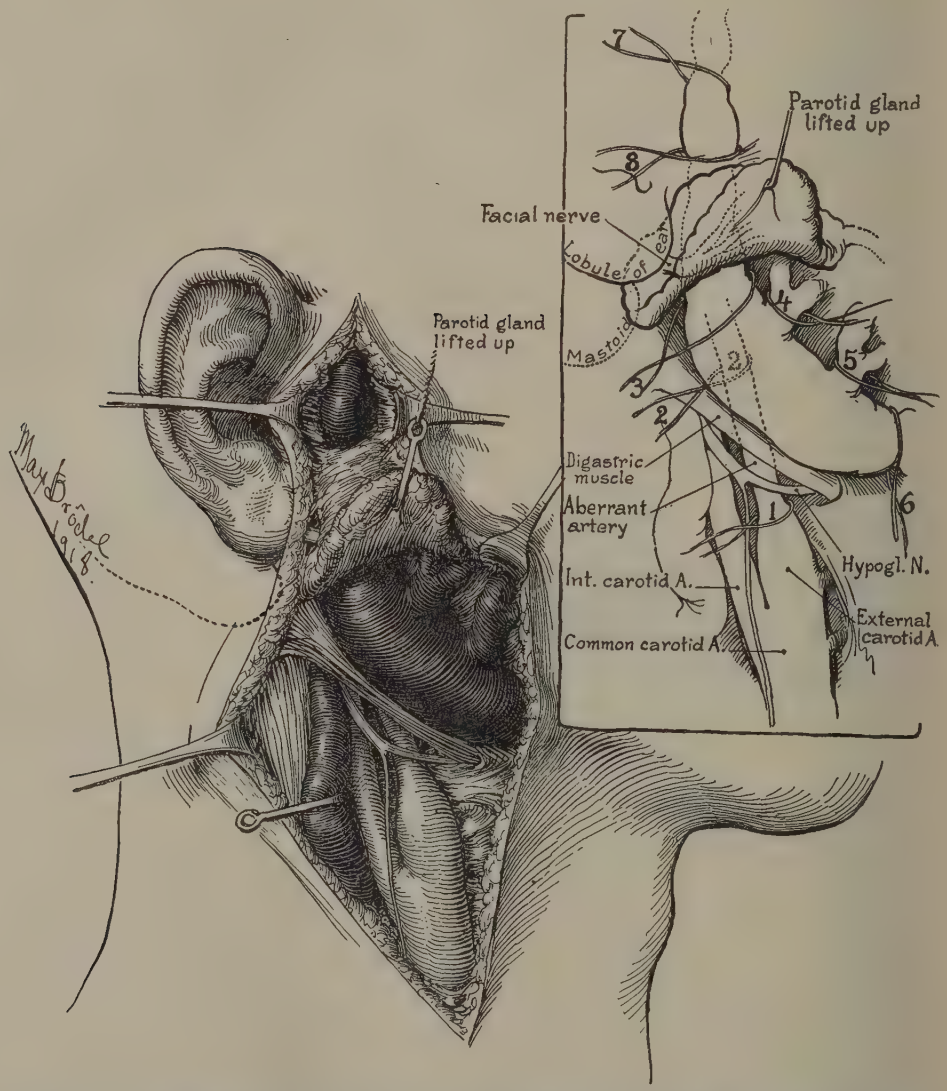


FIG. 52.—Appearances at the second operation. The internal carotid and the aberrant branch of the external carotid have become markedly enlarged, the fistula having shifted its position to a peripheral point.

The explanation of the findings is, I think, clear. There were originally two fistulae. The chief of these being eliminated at the first operation, the second, distal to the first, functioned more and more freely in the course of the 6½ years. The internal carotid, small at the operation, being central

to the main fistula, dilated after the subordinate or distal fistula became active; and the anomalous artery, also central to the main fistula, became dilated for the same reason. In regard to the development of congenital arterio-venous fistulae Dr. Florence Sabin has kindly written me as follows:

"The anomaly of direct anastomoses between arteries and veins brings up an interesting point in the development of the vascular system, namely, that vessels which have served as arteries in the embryo may become veins and vice versa. One of the earliest examples of this occurs in the development of the vessels in the yolk sac of the chick. Primitively the anterior half of the yolk sac is entirely venous while the posterior half is entirely arterial, thus the omphalo-mesenteric vein and arteries are separated as far as possible by a wide capillary bed. Subsequently the omphalo-mesenteric arteries are accompanied by veins which develop as follows. As can be seen in Fig. 3, Plate 3, in Popoff's Atlas,[2] originally the omphalo-mesenteric arteries lie throughout their course in a capillary network. In the capillaries along the caudal border of the artery the blood flows away from the heart, while in those along its cephalic border it returns directly to the heart. As the chick develops, these two sets of capillaries along the main stem of the artery lose their connections with it and join each other, thus making a plexus which accompanies the artery and receives the blood which has passed out to the tip of the artery and returns it to the heart. In this plexus develops the vein which accompanies the artery. It is obvious that the retention of any of the original connections of these capillaries with the artery would form the basis of a direct anastomosis between an artery and a vein.

"In connection with the development of the veins of the head and neck, it has been shown that the internal jugular vein develops in three different segments. At first the blood of the cerebral veins, which make the first segment, passes through a long vein which rests on the hind-brain and ultimately becomes a plexus of vessels in the pia mater. From this deep vein the blood passes into the third segment, which is the anterior cardinal vein, and thence through the duct of Cuvier to the heart. This deep vein along the hind-brain is then eliminated from the drainage of the cerebral veins by the development of a chain of capillaries between the aorta on the one hand and the cerebral veins and the anterior cardinal vein on the other. This chain of capillaries rapidly enlarges into the middle segment of the internal jugular vein. The original connections with the aorta are shown injected in Fig. 1, Plate 1, Sabin (1917),[3] for a pig embryo with 23 somites, measuring 7 mm. Moreover, injections of pig embryos measuring 14 or 15 mm. may still show slender connections between this middle segment of the internal jugular vein and the internal carotid artery.

"From these examples it is obvious that the details of the origin of each vessel should be worked out as a basis for specific anomalies that may occur

[2] Popoff, D., 1894, "Die Dottersack-Gefässe," C. W. Kreidel's Verlag.

[3] Sabin, F. R., 1917, "Origin and Development of the Primitive Vessels of the Chick and of the Pig." *Ibid.*, Contributions to Embryology, No. 18, Publication 226 of the Carnegie Institute of Washington.

in them, as has not yet been done for the external jugular vein, but the underlying principle that arteries and veins develop out of a common capillary plexus forms the basis for the persistence of direct connections between them."

B. *Enlargement of the Heart in Cases of Arterio-Venous Fistula and Persistent Ductus Arteriosus.*—A particularly interesting result of our clinical and experimental studies of arterio-venous fistula is the discovery that enlargement of the heart probably occurs after a time, as a rule, in the major cases. For ten years or more we have noted the condition of the heart in our patients with arterio-venous fistula and have, I believe, quite invariably found it enlarged—strikingly so in several instances. Dr. Mont Reid, of our Surgical Staff, has in preparation a report upon his experimental and clinical work on arterio-venous fistula in which he will offer convincing proof of our view that the fistula in its consequences may profoundly affect the heart as well as the veins and arteries. Skiagraphs show the effects of a fistula made 3½ years ago by Dr. Reid between the carotid artery and external jugular vein of a dog. The veins of the neck on both sides are dilated and the carotid artery is dilated central to the fistula. The heart after two years showed slight enlargement, and now, after three years, it has become pronouncedly increased in size. If the assumption is correct that the heart dilates in consequence of arterio-venous fistula, it is important that the fact should be brought to the attention not only of surgeons, but also of pathologists and internists, who evidently have overlooked it.

Our experimental and clinical observations on arterio-venous fistula and partial occlusion of large arteries may ultimately aid in the explanation of the sequelae of certain congenital anomalies of the heart and aorta. May we not regard the persistent ductus arteriosus as an arterio-venous fistula, the pulmonary artery and the right heart representing the venous side of the fistula? The enlargement of the left heart we might assume for the moment to be somewhat analogous to the dilatation of the artery proximal to a fistula; and in the dilatation of the right heart and pulmonary artery we recall the dilatation of the veins.

My studies on the subject of the dilatation of an artery, which we find occurs distal to a constricting metal band and distal to the compression exercised by a cervical rib, have led me to investigate the results of the congenital coarctations of the aorta at or beyond its isthmus. I have been interested to find that in a large percentage of these cases of coarcted aorta there is dilatation, more or less delimited, beyond the site of the coarctation. The generally accepted view that this dilatation is to enable the aorta better to carry on the anastomotic circulation must, it seems to me, be erroneous. When we shall have ascertained more precisely the cause of the arterial

dilatation obtained experimentally below constricting bands and of the dilatation of the artery proximal to an arterio-venous fistula, we may be able to explain the dilatation of the aorta beyond the congenital coarctation.

C. *Plausible Explanation of the Presence of Blood in Lymph-Cysts at the Second and Subsequent Tappings.*—

A few years ago, assisted by Dr. Heuer, I removed from the abdomen of a woman about forty years of age a huge congenital hygroma or lymph-cyst. The diaphragm was pushed high up into the right thorax and the liver was displaced far to the right and so rotated on its vertical axis that its inferior border, instead of being transverse, was parallel to and almost in line with the linea alba. The enucleation of the greater part of the cyst was easily accomplished, the few adhesions being disposed of by gentle, blunt dissection. Finally, when there remained only a few filamentous fibers binding the sac to the right adrenal gland [4] and the inferior vena cava, we proceeded with even more deliberation and caution. The adhesions to the vein were so delicate that the gentlest manipulation with the handle of the scalpel sufficed to break them. We had an unusually free and clear exposure of the vein and were operating without embarrassment. Suddenly blood gushed from a linear defect about 3 mm. long in the vena cava. The haemorrhage was promptly controlled and the slit in the vessel sutured. Proceeding thereafter with perhaps even greater delicacy, we were again confronted with a gush of blood from the vena cava at a higher point. Here we found a slit about 1.5 cm. long in this vein. The edges of the slit were smooth, the linear defect being clearly not due to a tear or cut. The gap in the vein was closed by suture.

Dr. Heuer and I satisfactorily assured ourselves that there was no defect or special thinning of the wall of the cyst at the point contraposed to the larger of the two defects in the wall of the vena cava.[5]

The defects or slits were surely not artefacts. They represented, I believe, imperfectly closed embryonic communications between the vein and lymph buds or lymphatic vessels. Dr. Florence Sabin, to whom we owe so much for our knowledge of the origin and development of the lymphatic and vascular systems, writes me in regard to this case as follows:

"Recent work on the lymphatic system serves to demonstrate that lymphatic vessels are modified veins. It has been shown that lymphatic vessels occur first in the neck as sacs, lined with endothelium and packed with blood, which lie close to the jugular veins. The abdominal lymphatics begin

[4] The relation of the cyst to the right adrenal gland was remarkable. In the course of stripping the sac's final delicate attachments we exposed a flat, black surface, evidently the spread-out medulla of the adrenal, about the size of a half dollar; parenchymatous oozing from this surface required for its arrest a few mattress sutures of fine silk.

[5] The patient recovered promptly and has enjoyed excellent health since the operation.

as a sac which lies close to that part of the inferior vena cava which connects the two Wolffian bodies. Baetjer [6] showed in 1908 that in the pig this sac, which is the forerunner of the retroperitonaeal lymphatics, communicates for a time with the inferior vena cava. These communications between the lymphatics and the abdominal veins, which are transitory in the pig, were then shown to be permanent in the South American monkeys by Silvester in 1912,[7] while in 1915 Job [8] demonstrated similar permanent connections in rodents. Thus the study of the development of the lymphatic system affords an explanation of anomalies involving connections between the lymphatic vessels and both the renal veins and the inferior vena cava." [9]

The statement has repeatedly been made that hygromata which at the first tapping have yielded a clear fluid may be found at all subsequent tappings to contain more or less blood. Only one explanation has been offered for the presence of the blood, viz., trauma of the wall of the cyst. This explanation has always seemed to me an unsatisfactory one, because the walls of these cysts are as a rule very thin and nonvascular. May it not, in view of the findings in our case, be possible that vestigia of lymphatico-venous communications (*vid.* Plate XLII) are responsible for the admixture of blood which has occasionally been noted at only the second and subsequent tappings of lymph-cysts and is more frequently found at the first tapping? The negative pressure consequent upon the aspiration of fluid from the cyst might divert for the moment a little blood from the vein which had given origin to the hygroma's lymphatic bud or vessel. Thus the contents of the sac, clear at the first withdrawal, would be blood-stained at the second. Thereafter, with each tapping blood would be aspirated into the sac and hence clear fluid might never again be obtained.

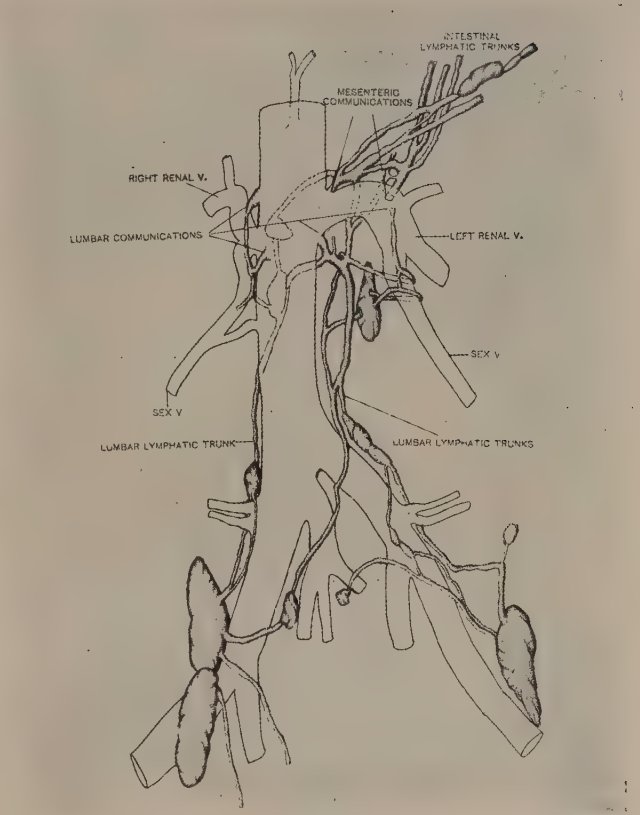
[6] Baetjer, W. A., 1908, "On the Origin of the Mesenteric Sac and the Thoracic Duct in the Embryo Pig." Am. J. Anat., viii.

[7] Silvester, C. F., 1912, "On the Presence of Permanent Communications Between the Lymphatic and Venous Systems at the Level of the Renal Veins in Adult South American Monkeys." *Am. J. Anat.*, xii.

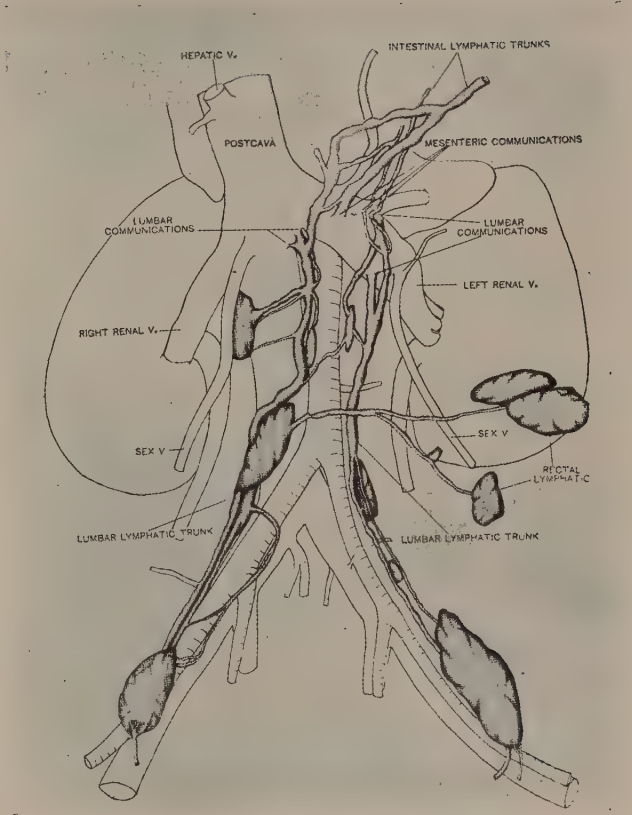
[8] Job, T. T., 1915, "The Adult Anatomy of the Lymphatic System in the Common Rat," *Anat. Rec.*, ix.

[9] Sabin, F. R., 1913, "The Origin and Development of the Lymphatic System," *Johns Hopkins Hosp. Rep.*, Monographs, New Series, No. v.

Ibid., 1915-1916, "The Method of Growth of the Lymphatic System." The Harvey Lectures, Series xi, J. B. Lippincott Co.



1.—Cebus Hypoleucus, Humb. (White-throated Capuchin.)



2.—Atelas Variegatus, Wagner. (Variegated Spider-monkey.)

(Reproduced from Charles F. Silvester's paper (*l. c.*) with the kind permission of the author and the editors of the *American Journal of Anatomy*.)

LIGATIONS OF THE LEFT SUBCLAVIAN ARTERY IN ITS FIRST PORTION[1a]

In a delightful discourse " on arterio-venous aneurism Osler takes a swift flight into a vibrant domain of surgery, tracing into and out of the dark ages steps of the few surgeons who blazed the way. Well he knew and loved the crystal springs and sources bearing their tiny freights of knowledge to the flood. Readers of *The Johns Hopkins Hospital Reports* will welcome the quotation from Sir William's paper:

" Better than any other disease aneurysm illustrates how borderless are the boundaries of medicine and surgery. Here am I talking on the most surgical of all its aspects, while very likely not far away a surgeon is practising the best possible prevention against internal aneurysm in giving a syphilitic patient an injection of salvarsan! Aneurysm has been a medico-chirurgical affection ever since some bungling young 'minutor' first nicked the brachial artery in performing venesection. One of the earliest and most interesting references in literature is to an instance of this kind. Galen was called in consultation by a young and inexperienced surgeon who had opened the artery at the bend of the elbow instead of the vein, and the blood spurted out 'clarus, rubens, lucidus et calidus.'

'I took in the situation at once; there happened to be an elderly physician with me, so we prepared a medicine, viscid, conglutinable, and obstructive, and placing it strongly against the lips of the wound bound over it a soft sponge. The surgeon who had opened the artery wondered, but said nothing. When we went out [note the professional touch!] I said to the surgeon that he had opened the pulsating vessel and charged him not to dress the wound before the fourth day, and not without me.'

" The cure was complete, and Galen remarks that this was his only successful case of the kind, as in all others aneurysm had followed. This account, taken from Symphorien Campegius *Claudii Galeni Pergameni Historiales Campi, Basilae, 1532, p. 43,* is doubtless of the case referred to in the *Methodus Medendi.*† The only other references to aneurysm in Galen are in the *De Tumoribus praeter Naturam* ‡ and in the *De Curandi Ratione per Sanguinis Missionem,* § in which he refers to the possibility of gangrene.

Historical Survey

" Rational surgery was one of the gifts of the Greeks, but in the 800 years between Hippocrates and Oribasius few names have survived specially

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† " Linacre's edition, 1517, f. lxii, v."
‡ " Junta, fifth edition, 1576, iii, p. 84."
§ "*Ibid.*, vi, p. 21."

associated with this branch of medicine. Who among us off-hand could recall more than two or three in addition to Hippocrates and Galen? Yet in this period scores of important schools flourished with great teachers of surgery, men honoured in their generation and the glory of their times. As one reads the partial list in Haller's *Bibliotheca Chirurgica* and scans the few golden remains of their writings fortunately preserved by encyclopaedists such as Oribasius and Paul of Aegina, the truth of Sir Thomas Browne's remarks comes home: 'Who knows whether the best of men be known, whether there be not more remarkable persons forgot than any that stand remembered in the known account of time?' Two of these comparatively unknown men created the surgery of arteries, Rufus of Ephesus and Antyllus, the Cosmas and Damien of Greek surgery.*

RUFUS OF EPHESUS

"To generations of practitioners unworthy to hand him ligatures Rufus of Ephesus (Reign of Trajan, early part of second century A. D.) was known by the 'pilulae Ruffi,' 'the pills I would not be without'—'pilulae sine quibus esse nolo'—still in the British Pharmacopoeia as the pill of aloes and myrrh. In the brilliant Ionian profession of the early days of our era Rufus doubtless had predecessors and teachers, but he stands out a strong, clear figure, a great 'magister chirurgiae,' a title justly earned by his remarkable contribution to the surgery of haemostasis. We know it only through a section in Aetius, a sixth-century physician.† Nothing is lacking in a description, which might be transferred to any modern textbook—digital compression, styptics, the cautery, torsion, and the ligature—only I am sorry not to find, as is sometimes said, a description suggestive of arterio-venous aneurysm, though he speaks of the possibility of traumatic aneurysm.

"Through the Arabians the name of Rufus was on the lips of every mediaeval physician, and we find him among the favorites of Chaucer's well-read Doctor. In one of the earliest and most beautiful of medical manuscripts, the famous *Juliana Anicia Dioscorides* (A. D. 525), of the Vienna Library, he is figured with Galen, Hippocrates, and others.

ANTYLLUS

"Upon the other great surgical figure of antiquity, Antyllus, so blindly has oblivion scattered her poppies, to quote Sir Thomas Browne again, that not a fact of his life is known; yet through the mists of 18 centuries he looms large as one of the most daring and accomplished surgeons of all time. A resector of bones and joints, one of the first to perform tracheotomy, the founder of the surgery of fistula, a successful operator upon cataract, and

* "These practitioners, who became the Christian saints of surgery, suffered martyrdom in Cilicia in the third century. In their Western Mother Church, on the Roman Forum, I have seen the little parcel said to contain the instruments with which they performed the most famous operation in hagiological surgery, substitution of the healthy thigh of a just-dead man for one that was gangrenous."

† "Tetrabiblos, lib. xiv, cap. 51."

we may say the creator of the surgery of the arteries—these are among his known achievements. His remains are chiefly in the works of Oribasius, the physician and friend of the Emperor Julian.

"Nowhere are we impressed with the note of directness so characteristic of the Greek (see R. W. Livingstone's *Meaning of the Greek Genius, second edition, 1915*) as in the brilliant account given by this author of aneurysm, of which he was the first to recognise two forms—one by dilatation, the other following wound of the artery. So far as I can gather, he was also the first to describe the thrill or bruit so characteristic of the latter form. No ancient writer has anything like the same accuracy of pathological description, and you may search the surgical literature for centuries before there is found such a gem as the account of his method of operation still in use, and by which his name has been permanently enshrined. Not finding one in English, I asked Mr. Livingstone, of Corpus Christi College, to give us a complete translation of the fragment.

ABOUT ANEURISMS (FROM THE WORKS OF ANTYLLUS *)

'There are two different kinds of aneurysms. The one kind occurs when there is a local dilatation of an artery (this was the origin of the name aneurysm or dilatation). The other kind arises from the rupture of an artery and the discharge of the blood into the flesh beneath it. Aneurysms due to the dilatation of an artery are longer than others; those due to a rupture are rounder. In the former there is a thicker layer of tissue; in the latter you can hear a certain crepitation if you press them with your finger; while in aneurysms due to dilatation there is no sound.

'It is foolish to follow the practice of the ancient surgeons and decline to treat any aneurysm, but it is dangerous to apply surgical treatment to all types. Se we will excuse ourselves from treating aneurysms in the armpit, groin, and neck, on the ground that the vessels are large and that it is impossible or dangerous to isolate and tie them. We also decline exceptionally big aneurysms, even if they occur elsewhere. But we will operate as follows on aneurysms in the extremities, the limbs and the head.

'If the aneurysm results from dilatation, we will make a straight incision in the skin the whole length of the vessel; then, after separating the edges of the incision with hooks, we will carefully sever all the membranes between the skin and the artery. Then pushing aside with blunt hooks the vein adjacent to the artery, we will expose the dilated portion of the artery on all sides. Next, we will introduce the head of a probe underneath, and, lifting the aneurysm, insert along the probe a needle with a double thread, so that it passes beneath the artery. We will cut the threat at the eye of the needle, making two threads and four ends of thread; then, taking the two ends of one of the threads, we will pass them gently to one end of the aneurysm and tie them with precision. Similarly, we will pass the other thread to the opposite end of the aneurysm, and then tie up the artery, so that the entire aneurysm lies between the two ligatures. Then we will lance the aneurism with a small incision at its centre; in this way its contents will all be evacuated without any danger of haemorrhage. Those who tie the artery, as I advise, at each extremity, but amputate the intervening dilated part, perform a dangerous operation. The violent tension of the arterial pneuma often displaces the ligatures.

'If the aneurysm originates in the rupture of an artery, isolate with your fingers as much of the aneurysm as you can, including the skin. Then below the isolated part introduce a needle with a double thread of flax or of gut; after passing it through, cut it at the needle's eye forming two threads. Take hold of the two ends of one of these and pass it to the right, there tie it tightly, so as not to slip. Pass the other end similarly in the opposite direction—to the left. If there is any fear of the threads slipping, pass a second needle with a similar double thread through the same spot, intersecting the first thread and crossing it in the form of the letter X

* "Oribasius, iv., p. 52 (ed, Daremberg)."

(chi). Cut the threads as before, and tie them like the first ones, so that four threads form the ligature. Then open the tumour at its top, and, after evacuating the contents, remove the superfluous skin, leaving the part tied by the threads. In this way the operation is effected without haemorrhage.'

"And I must read Mr. Livingstone's comment:

'It certainly is a beautiful piece of lucid writing. I felt that if I was alone on a desert island with someone suffering from aneurysm, and the tide had washed ashore sufficient αγκιστρα, etc., that I shouldn't have minded trying the operation. And Antyllus had real literary power. What an admirable phrase is εκπτυεται, the "spitting out" of the ligature by the throbbing artery: I don't think you can get it in English, and I fell back on a lame substitute, "displaces."'*

"Not unjustly does Paul Broca in his great monograph, *Des Anévrismes,* claim that not only did Antyllus create operative medicine but the pathology of aneurysm: 'A chaque ligne on reconnait l'écrivain qui parle de ce qu'il a fait.'

Decay and Revival of Vascular Surgery

"Aetius in the middle of the sixth century describes the method for cure of aneurysm at the elbow, known later as that of Anel (1710), ligation of the brachial artery three or four fingers' breadth below the axilla, followed by opening the sac, which was allowed to heal by suppuration. A curious error of Sprengel has led to the connexion of the name of Philagrius,† a fourth century surgeon, with this operation. In the fragments of this writer given by Aetius aneurysm is not mentioned, but Sprengel never noticed that the extract on aneurysm which follows directly after one upon ganglion by Philagrius did not belong to this author but to Aetius himself.

"A casual perusal of the fragments of the Greek surgeons of the first three or four centuries of our era as given in Gurlt's *Geschichte der Chirurgie* gives the impression of a great and fruitful period with scores of men whose qualifications were those demanded by Thomas Fuller for the good operator—the eagle's eye, the lion's heart, and the lady's hand. Then came the tragedy, the death in the West of the science of the Greeks. The Church took over their philosophy, the Arabs absorbed much of the best of their medicine and added to it, but surgery as a progressive science and a successful art died with its founders, the great Greeks of the Graeco-Roman Empire. So far as the surgery of arteries is concerned we might take a jump of a thousand years or more were it not for an Arabian, Albucasis of Cordova (tenth century), who wrote a famous surgical treatise, of which we have in the Bodleian the two earliest manuscripts. A young scholar of Wadham and Student of Christ Church, John Channing, in 1778 issued

* "Blows off" might serve—the expression fits the conception of air (πνεῦμα) in the arteries. But it is difficult, as Mr. Livingstone remarks, to improve upon "spits off," for to spit one inflates the lungs. (W. S. H.)

† The method ordinarily attributed to Philagrius is the one practised by Purmann[48] (1680)—an aneurismectomy. For the seemingly final word on the subject of the operations for aneurism of Philagrius and Antyllus the reader is referred to the illuminating paper of Köhler.[28] It would lead us too far afield to follow him through the mazes of the discussion or even to indicate the ramifications of the contradictions found in the most authentic documents. We must for the present accept the conclusions reached by this painstaking scholar. (W. S. H.)

from the Clarendon Press a beautiful edition. The description which he gives of aneurysm with its treatment is practically that of Antyllus. He notes the stridor to be felt, which indicates that he was probably dealing with the arterio-venous form.

"In vascular surgery the men of the Middle Ages and of the Renaissance, Henri de Mondeville, Guy de Chauliac, and even Ambroise Paré, were blind followers, who never even approached the position of their masters. Not much more than a century has passed since men of the John Hunter type took up vascular surgery where Rufus and Antyllus had left it. You may think, perhaps, that I am scarcely just to the great mediaeval surgeons, particularly to such a master as Ambroise Paré, who reintroduced the ligature, but in vascular surgery, the touchstone of the position of the art, they never wholly regained what the profession had lost." *

What surgeon called upon to treat a huge aneurism of the neck or groin has not experienced the disturbing sensations which only such tumors can arouse? When confronted with an inoperable, malignant neoplasm one feels the great pity of it but not, as in the case of an aneurism, a peremptory challenge to face the exigency and cope promptly with a situation demanding skilful, resourceful, and possibly even temerous intervention. Few of the surgeons to come will have occasion to be stirred as Valentine Mott must have been by his dramatic experience in ligating the common iliac artery. The surgeon of today looks rather to science than to his art for stimulating rewards of his endeavor. In ligating the first portion of the left subclavian within the chest the operator may not, as formerly, be more greatly impressed by the magnitude and cleverness of his performance than by the miraculous effect of the ligation of the artery upon the great, pulsating tumor which with each beat of the heart jarred the whole frame of the sufferer. The moment of tying the ligature is indeed a dramatic one. The monstrous, booming tumor is stilled by a tiny thread, the tempest silenced by the magic wand.

We have reports of several aneurisms of the subclavian artery which may have been quite as large as the one which I am about to record, but no one of these was operated upon.

Huge Subclavian Aneurism. Ligation of the First Portion of the Left Subclavian Artery, and, Two Years Later, Excision of the Contracted Tumor

Sur. No. 46179. Alexander Miller. Negro, aet. 29. Admitted to The Johns Hopkins Hospital, April 22, 1918; discharged August 12, 1918.

The patient states that he has always been perfectly well. In April, 1917, he noticed a swelling about the size of an egg above the left clavicle. Almost

* True also it is, as I have often said, that the surgeon's method of dealing with the blood vessels is a criterion of his proficience in his art. (W. S. H.)

simultaneously with the recognition of the swelling, pain and numbness in the upper extremity were observed. The growth of the tumor was gradual until about March, 1918; since then it has been very rapid. For the past two weeks the limb has been totally paralyzed. The patient recalls that until Christmas, 1917, he could still raise his arm a little.

About four years before admission the patient was shot just above the left clavicle. The wound healed promptly. The bullet was not removed and has given him no indication of its presence.

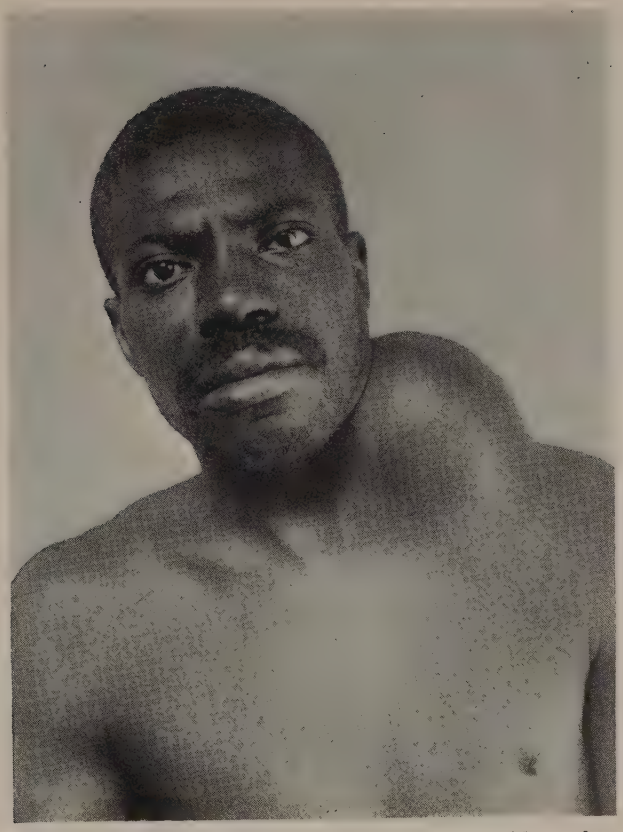
Examination.—The patient is evidently suffering severe pain, and constantly supports his left wrist with his right hand. The pain, he says, is most intense from the elbow joint to the hand and in the left shoulder.

A huge aneurism occupies the left neck from the clavicle to the ear (Plate XLIII, 1 and 2). The head is deflected and rotated to the right. The vertex of the pulsating mass is about on a plumb-line dropped to the junction of the middle and inner thirds of the clavicle. The swelling and pulsation extend on to the chest, and the whole body is jarred with each heartbeat. Posteriorly the diffuse pulsating tumefaction spreads out to a point below the spine of the scapula. The aneurism extends upward in dome-shape; a hand can be inserted between it and the face down to the angle of the lower jaw. The whole shoulder-girdle appears to be raised away from the chest wall, the acromioclavicular articulation being apparently disrupted. The skin over the tumor is extremely tense and glistening. From the clavicle to about the level of the nipple the brawny tissues are probably infiltrated with blood as well as inflammatory products. The trachea is displaced to the right. A systolic bruit, most distinct above the inner third of the clavicle, can be heard over the greater part of the pulsating mass. No thrill can be felt. The left radial pulse is absent. There is slight ptosis of the left eyelid, but the pupils seem to respond equally. Only the inner third and the acromial tip of the clavicle can be defined with the fingers; the remainder of the bone is buried in the tumefaction. A bullet is palpable just beneath the skin to the left and below the spine of the seventh cervical vertebra. The muscles of the left shoulder, arm, and forearm are paralyzed; there remains a trace of power to flex the fingers and wrist. The deep reflexes are absent and the muscular atrophy is marked. The entire extremity up to and over the aneurism is insensitive to touch, pin-prick, and temperature.

Fluoroscopic Examination.—The shadow of the aneurism extends to the lower border of the clavicle but not to the first rib. The heart seems not to be enlarged. The right subclavian and carotid arteries, distinctly seen, are normal in size.

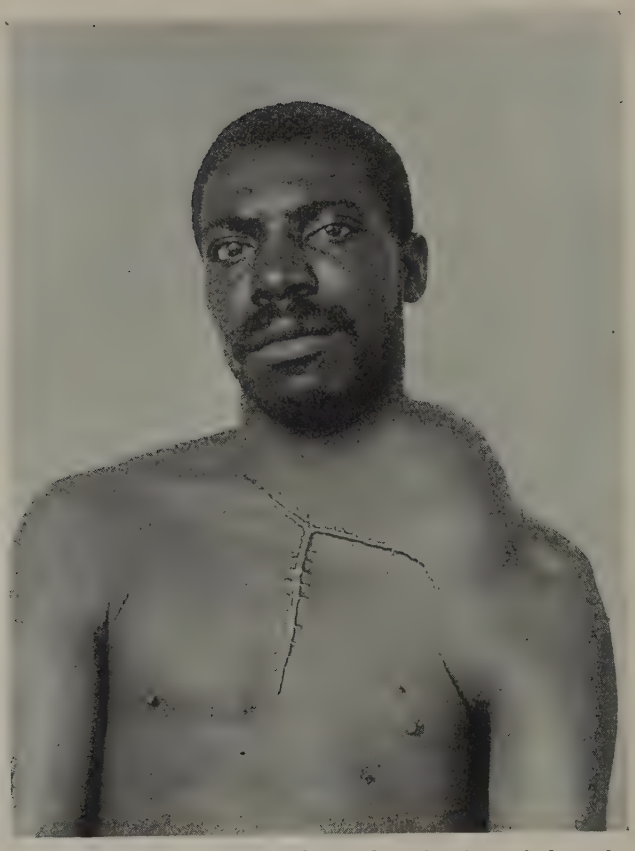
Skiagraphic Report.—Large mass in left neck. Clavicle deeply eroded, perhaps fragmented. Bullet in upper dorsal region.

The thought of excising or incising the aneurism was hardly entertained. The patient's condition contraindicated such a prolongation of the intervention, and an operation on so large a scale and through so great an expanse of infiltrated and inflamed tissues might have menaced from infection the life of the patient and have imperiled the artery at the site of the ligature, deep within the thorax.



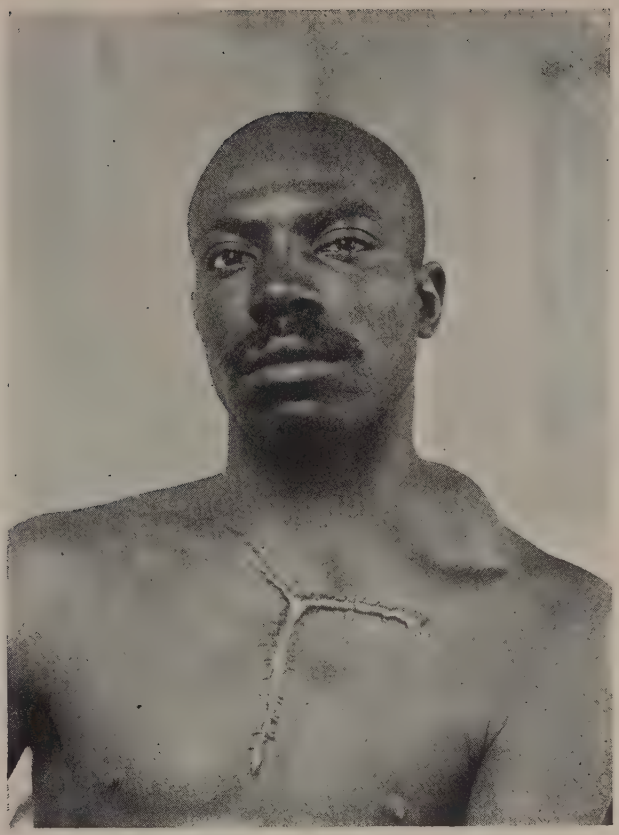
1.—Aneurism of the left subclavian artery, Alexander Miller, April 22, 1918.

2.—Alexander Miller, April 22, 1918.

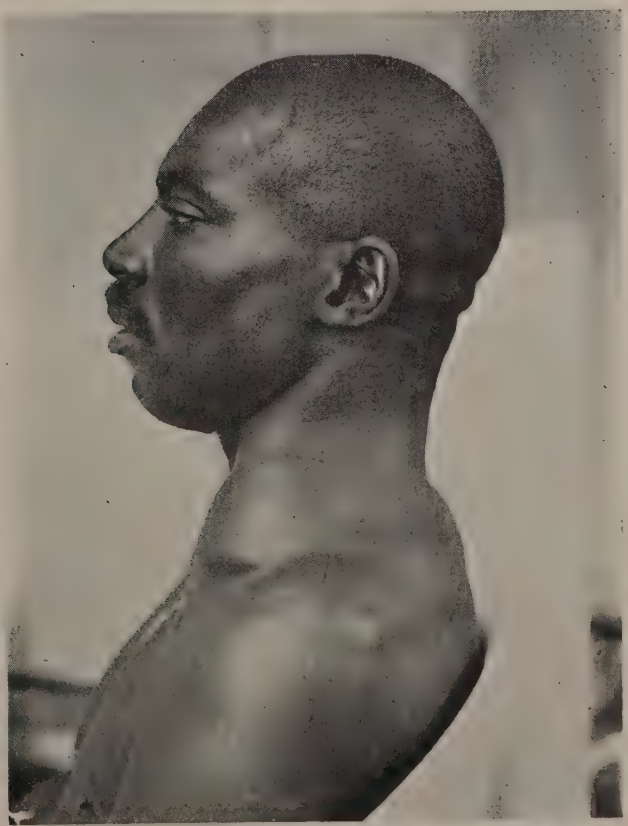


1.—Alexander Miller, 109 days after ligation of the subclavian artery near its origin.

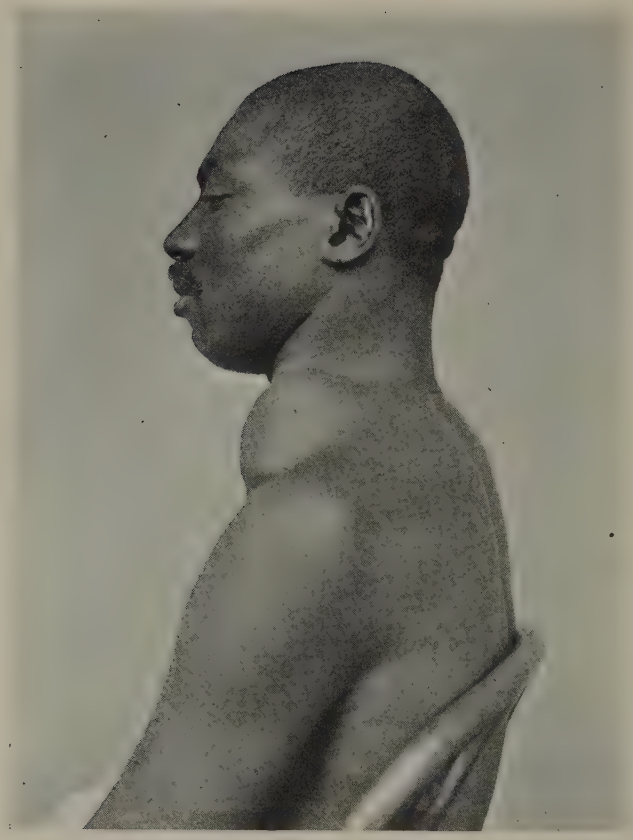
2.—Alexander Miller, 109 days after the ligation.



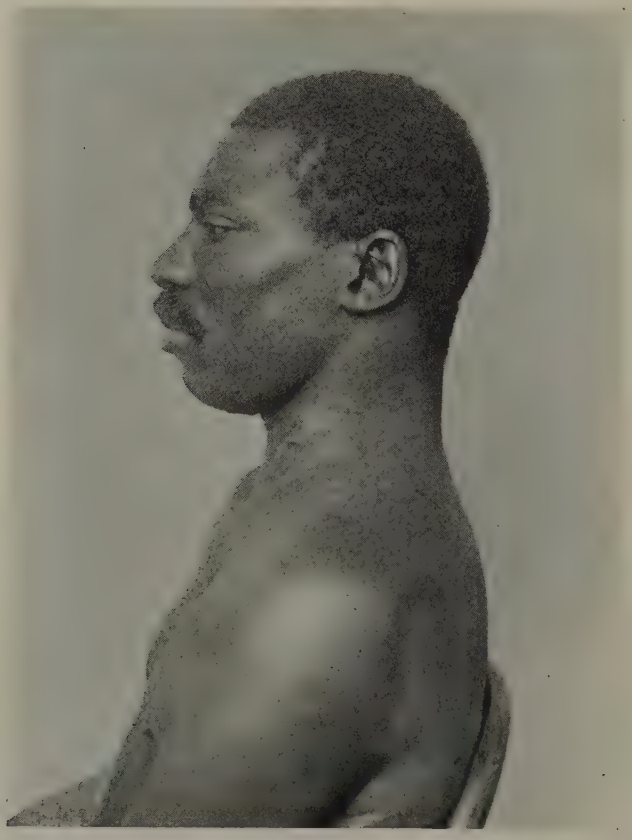
1.—Alexander Miller, 10 months after the ligation.



2.—Alexander Miller, 10 months after the ligation.



1.—Alexander Miller, 2 years after the ligation of the subclavian, and 2 weeks before the excision of the aneurism.



2.—Alexander Miller, 1 month after excision of the aneurism.

Operation, April 26, 1918.—Dr. Halsted. *Ligation of the left common carotid and the left subclavian arteries near their origin from the aorta.*

Ether. Wide protection of the operative field with celloidin silk.[20]

Transverse bow-incision just below the cervicothoracic junction, supplemented by a vertical one along the left border of the sternum (bow and plummet incision). Free exposure of manubrium and left sternoclavicular joint. The incised tissues were oedematous, particularly so below the clavicle. The superficial vessels were abnormally large. Careful haemostasis by the fine silk transfixion method. The left two-thirds of the manubrium and the left sternoclavicular joint were resected with the giant rongeur forceps of Esmarch, care being taken to avoid disturbing the fragments of the eroded clavicle. The thymus gland and the left innominate vein were drawn upward and to the right with a retractor.

The trachea in the thorax, as well as in the neck, was displaced to the right by the pressure of the aneurism. The left carotid, deeply situated and occupying the midline in the chest, was gently occluded with a broad tape ligature. This artery was thought at first to be the left subclavian inasmuch as, according to the erroneous testimony of an onlooker, its occlusion did not affect the pulse in the left temporal artery, and lessened the force of the pulsation in the aneurism. To obtain access to the left subclavian artery the cartilage of the left first rib and the adjoining margin of the sternum were cut away. The arch, the aortic isthmus and descending aorta, and the left auricle of the heart were palpated with the finger of the operator before the left subclavian, lying close to the vertebral column, was identified. With the aid of four long, narrow dissectors, two of which were manipulated by the operator and two by Dr. Mont Reid, the vessel was clearly exposed at its origin from the aorta and for several centimeters distal to this point. As it was evident that none of the various aneurism needles was suitable for the passage of a ligature at this depth, a narrow blunt dissector, slightly curved and pierced at its tip, was armed with fine silk and passed under the artery. By means of this thread and then another, narrow linen tapes were drawn under the subclavian; both of these were tied, the second distal and close to the first, with force only sufficient to close completely the artery's lumen. The aneurism became very tense and hard immediately after the ligation, but was pulseless.

The patient's condition, bad on admission and particularly so just before operation, caused us some anxiety. Traction within the thorax on the branches of the aortic arch or on the pulmonary artery affects unfavorably and eventually disastrously the action of the heart. The pulse, about 120 at the beginning, was 140+ and quite weak at the termination of the operation. The wound was completely and accurately closed with interrupted sutures of fine silk. A great dead space in the mediastinum was, naturally, unavoidable.

Healing *per primam.*

November 9, 1918.—The patient has been examined frequently since his discharge from the hospital. He can make slight movements with the left fingers, otherwise there has been no appreciable return of power or sensation in the paralyzed arm. There has been no pulsation in the aneurism since the operation. The mass has steadily but slowly been absorbed.

Throughout the year following the operation the pulseless tumor slowly but steadily diminished in size. Then for a year the patient, living out of town, was lost sight of. Exactly two years after the first operation he returned, at our solicitation, to the hospital. Now for the first time since the operation a very faint pulsation was discernible. The tumor (Plate XLVI, 1) measured in its transverse (frontal) diameter precisely the same as when last seen a year before; the antero-posterior measurement (sagittal), however, gave an increase of about 4 cm. Sensation of the left shoulder, arm, forearm, and hand was quite normal except for slight impairment to touch and pin-pricks at the finger-tips and over the palm of the hand. Power had returned to the deltoid, supraspinatus, pectoralis major, and rhomboid muscles, and in slight degree to the biceps and triceps. From the atrophied infraspinatus there was no response. The patient was unable to pronate or supinate the forearm but he could slightly flex and faintly extend the wrist. For the interossei and lumbricales no improvement was observable.

I decided that the aneurism should be excised, and on April 20, 1920, operated as follows:

The skin over the tumor and a wide area about it were protected with Chinese silk dipped in celloidin. The incision, made through the tightly adherent silk, ran with the clavicle in its central part, curving up into the neck at its inner end, and down along the cephalic vein at its outer. Superimposed on and not attached to the greatly broadened and thickened clavicle was a sharply convex bow of bone about 9 cm. long and 6 mm. thick. This bow, recognizable in the photograph (Plate XLV, 2), was cut away and the clavicle bitten through with a heavy rongueur forceps at two points as close to the aneurism as possible. The cephalic vein was divided, and the axillary artery—pulseless, tape-like,* reduced in size, apparently not quite empty—was ligated about at the junction of its first and second portions, through a split made in the pectoralis minor muscle; the aneurismal sac and the resected rib were excised in one piece. The aneurism was matted to the surrounding parts by dense connective tissue, and hence had to be carved out rather than enucleated. The identification and freeing of the roots of the brachial plexus, which were in places embedded in the wall of the sac, consumed much time. The operation was conducted in a bloodless manner until nothing remained to be done except to divide the narrow neck of the sac. The tissues of this neck proved to be thin and friable, and the patient lost a few cubic centimetres of blood through a little tear, which was readily repaired with three stitches of fine silk. The wound was closed

*I have several times made the observation, both on the human subject and animals, that a stretch of artery destined to become obliterated may be partially or totally collapsed beyond the point of occlusion and nearly to the first distal branches although the blood pressure in the vessel peripheral to these branches may be approximately normal (*vid.* Jour Exp. Med., 1916, xxiv, 276). Hence I have questioned the validity of the universally accepted view that the conversion of the artery into a fibrous cord is due primarily to the thickening of the intima. May not the lowering of the blood pressure in the discarded, pocketed segment be the primary factor?

without drainage. I am greatly indebted to Dr. Heuer and Dr. Reid for their skilful and highly competent assistance which enabled me without fatigue to conduct the operation to a satisfactory conclusion. The excised aneurism was carefully examined by Dr. MacCallum, Dr. Reid, Dr. Heuer and myself and the decision reached that no portion of the artery had been excised.

At the first dressing, made on the 10th day after operation, it was noted that a little fluid had accumulated in the outer part of the wound. This was evacuated by puncture with a wooden toothpick wrapped with a few fibres of cotton dipped in pure carbolic acid. Closure of the puncture was prevented by the reapplication of the acid in the same manner on two alternate days. The introduction of a drain of any kind we scrupulously avoid. The word "drainage-tube" is in disfavor in our clinic. Should a wound become infected, tubes would be properly introduced for the purpose of disinfection, but not for drainage.

Noteworthy is the fact that the patient's hand, which prior to and ever since the first operation had been markedly cold, became strikingly warm about six hours after the second operation. It is improbable that the ligation of the cephalic vein was in any part responsible for this indubitable improvement in the circulation. The elevation of the temperature of the hand and forearm must, I believe, be attributable solely to vasodilatation incident to the ligations and severings of the subclavian and axillary arteries (Leriche).[22]

Today (June 16, 1920), the 57th since the operation, the left hand and forearm are still warm—quite as warm as the right. There are a few well-defined, cooler areas, one of them to the outer side of and below the olecranon process of the ulna.

Analysis of the Results of Ligation of the First Portion of the Left Subclavian Artery

Six of the 21 cases (28.5 per cent) died; only two of these (Rodgers and Marchesano) were operated upon in the days before Listerism; in three (Bardenheuer, Kammerer, Duval), antiseptic precautions were observed; the remaining fatality (Lane) occurred in 1883. The wound of the first operation in Lane's case was closed and is believed to have healed *per primam;* the haemorrhage, noted two weeks after the first operation, may have been due either to the fineness of the silk ligature or to infection or to both; infection must have been the chief cause of the haemorrhage after the second operation. Bardenheuer's patient died 18 hours after a difficult, very extensive, and presumably bloody operation for carcinoma; Kammerer's lived one month, and died of secondary haemorrhage due to faulty ligature-material (catgut); in Duval's case the cause assigned for the sudden death a few hours after the operation was speculative. Thus, infection was responsible for three of the six fatalities, and a catgut ligature for a fourth. All of

the 10 cases operated upon in the last decade recovered. The 21 ligations of the first portion of the left subclavian were all except one (Bardenheuer) for aneurism. Of the recovered cases the aneurism was spontaneous in six, and of traumatic origin in nine. Of the spontaneous aneurisms Stonham's (IX) is the only one not pronounced cured by the simple ligation of the subclavian.* As the artery in this case coursed high in the neck and the aneurism was apparently at the highest point of the subclavian's arch, and as, furthermore, the radial pulse reappeared 24 hours after the ligation of the subclavian, it would seem that there must have been a well established collateral circulation before the first operation. May not a cervical rib have been the primary cause of this aneurism? The effect of merely tying the subclavian artery was tested in five (Browne, Rubritius, White, Ballance, Halsted) of the nine traumatic cases. If my case (XXI) had been observed for a period less than the two years we should have believed that the ligation alone had effected a cure in every instance. In Browne's case, to be sure, the axillary haematoma was evacuated, but as no bleeding ensued it may be classed in this group of cures by simple ligation. In three (Jüngst, Delbet, Wieting) of the remaining four cases of this traumatic group the blood sac was opened, evacuated, and stuffed with gauze. The haemorrhage was profuse on opening the sac in all the three cases, and in two of them (Delbet, Wieting) the tight stuffing was for the purpose of controlling it. In Jüngst's case a ligature was placed on each side of the slit in the artery made by the bullet, and in Delbet's the subclavian was ligated in its third portion also, in order to control the "formidable haemorrhage" which occurred on opening the sac. In the remaining one of the nine traumatic cases (Neff) the ligation of the subclavian was made for the control of haemorrhage resulting from a tear inflicted by the operator in the course of a dissection of the neck for the removal of enlarged lymphatic glands. For the remarkable operative and postoperative complications in this case the reader is referred to the abstract (XIII).

Thus the aneurism was cured by the simple ligation of the subclavian, whether proximal or distal to the branches of the first portion, in all the spontaneous aneurisms but one (Stonham), and in all but one (Halsted) of the traumatic variety. By reference to the diagrams (Figs. 53-56) we note at a glance that the ligature of the first portion was distal to the branches of this portion of the artery in eight instances (Rodgers, Marchesano, Schumpert, Browne, Newbolt, Wieting, Hamann, White) and proximal to them in six (Bardenheuer, Kammerer, Jüngst, Rubritius,

* The case of Schumpert (VI), however, was observed only for nine weeks, and of Newbolt for three months.

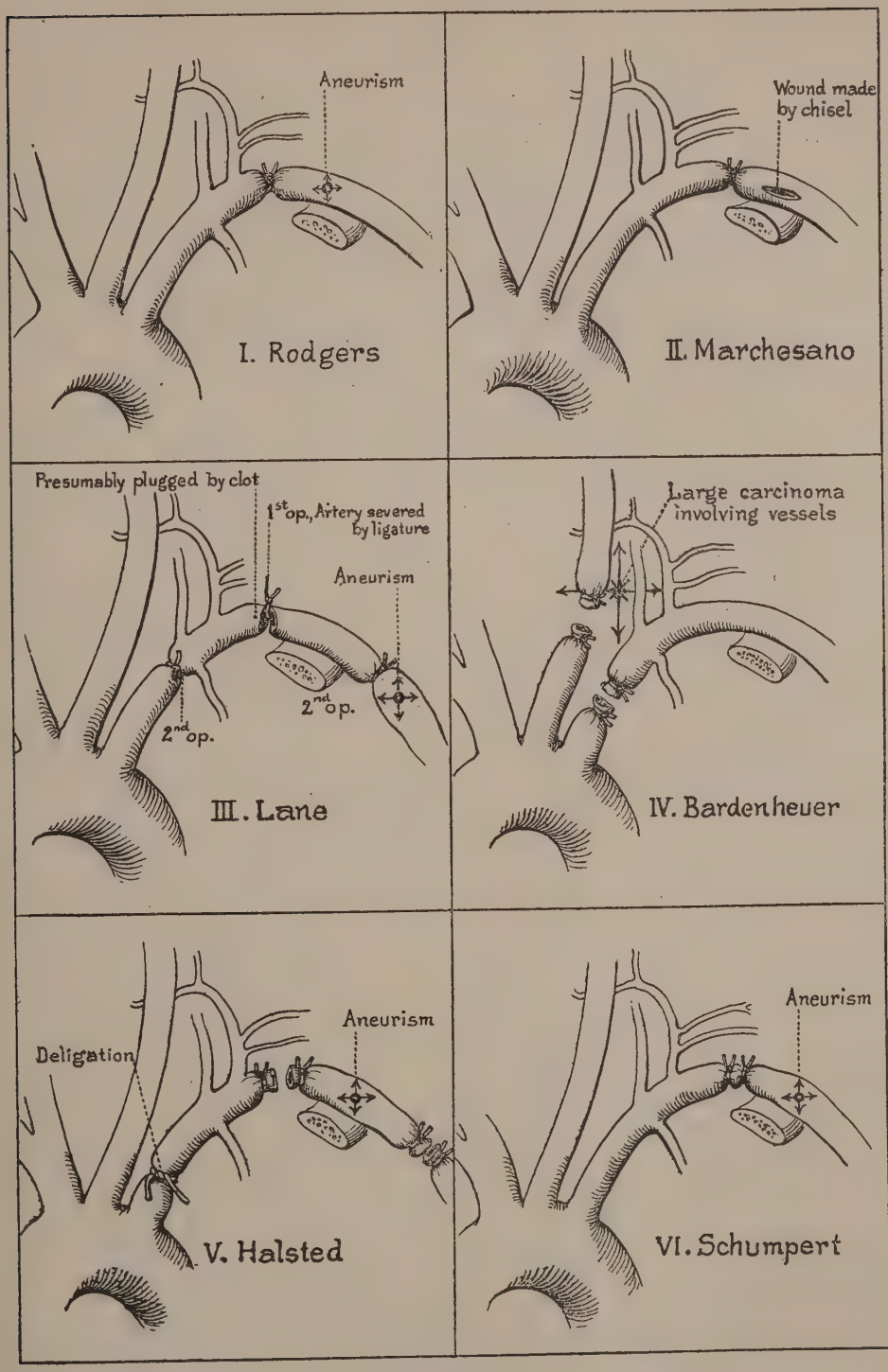

Aneurism
I. Rodgers
Wound made by chisel
II. Marchesano
Presumably plugged by clot
1st op., Artery severed by ligature
Aneurism
2nd op.
2nd op.
III. Lane
Large carcinoma involving vessels
IV. Bardenheuer
Deligation
Aneurism
V. Halsted
Aneurism
VI. Schumpert

FIG. 53.

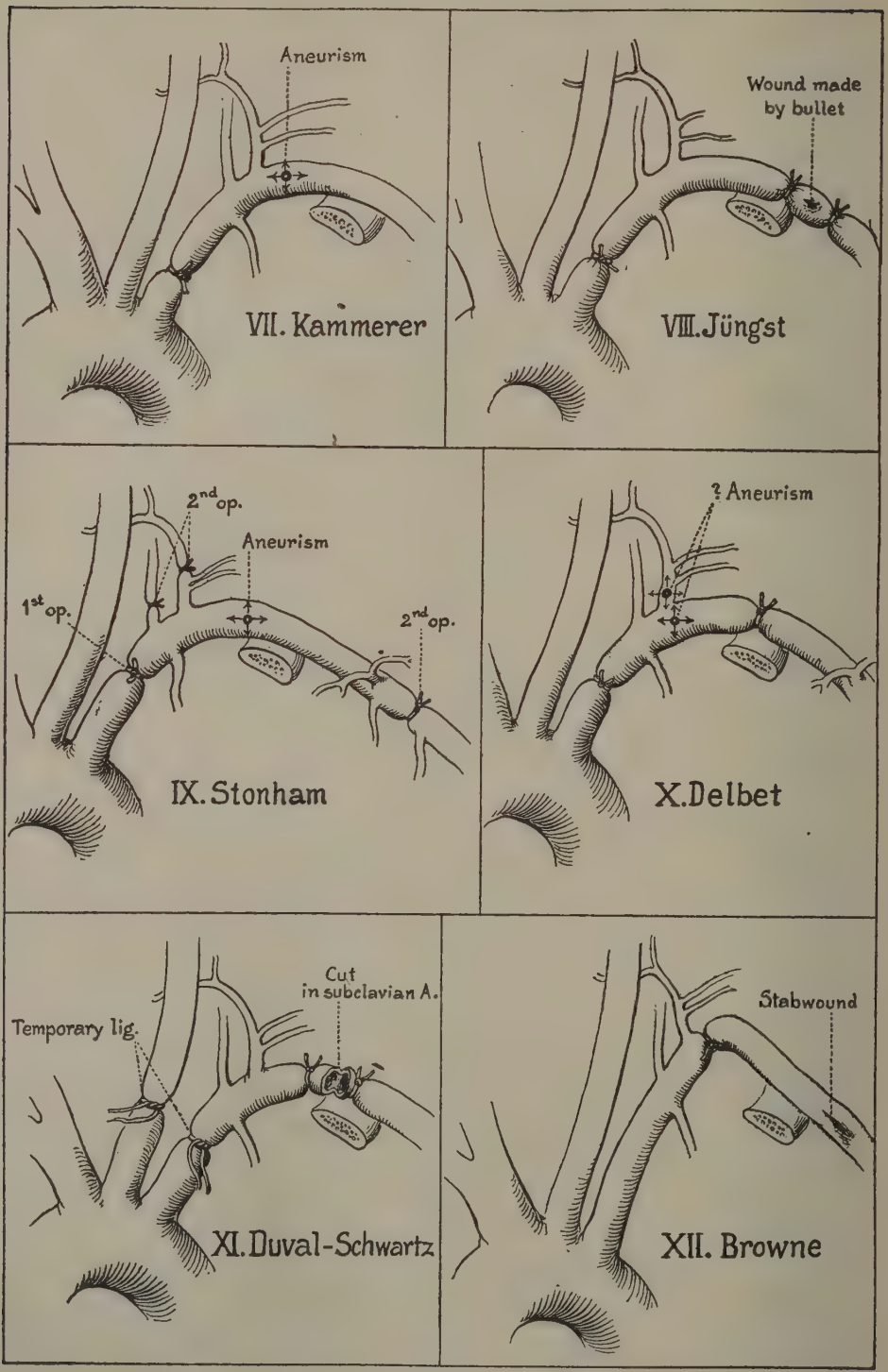

Aneurism
VII. Kammerer
Wound made by bullet
VIII. Jüngst
2nd op.
Aneurism
1st op.
2nd op.
IX. Stonham
? Aneurism
X. Delbet
Cut in subclavian A.
Temporary lig.
XI. Duval-Schwartz
Stabwound
XII. Browne

FIG. 54.

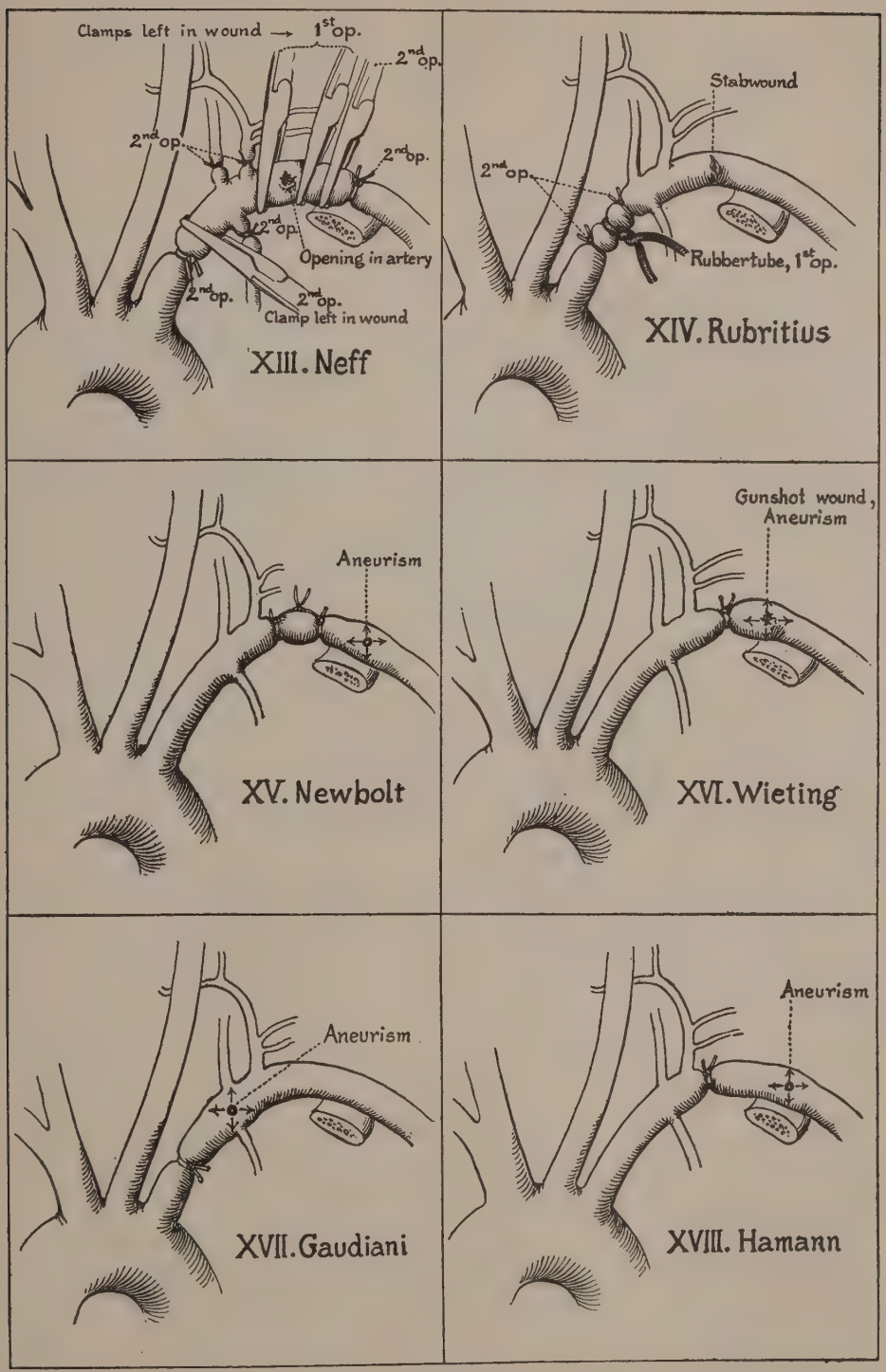

Clamps left in wound → 1st op.
2nd op.
2nd op.
2nd op.
2nd op.
Opening in artery
2nd op.
2nd op.
Clamp left in wound
XIII. Neff
Stabwound
2nd op.
Rubbertube, 1st op.
XIV. Rubritius
Aneurism
XV. Newbolt
Gunshot wound, Aneurism
XVI. Wieting
Aneurism
XVII. Gaudiani
Aneurism
XVIII. Hamann

FIG. 55.

Gaudiani, Ballance *). In seven of the cases (Lane, Halsted, Stonham, Delbet, Duval, Neff,† Halsted) the subclavian was ligated on both sides of the origins of its branches, and in two of these (Halsted, Halsted) the aneurism was excised.

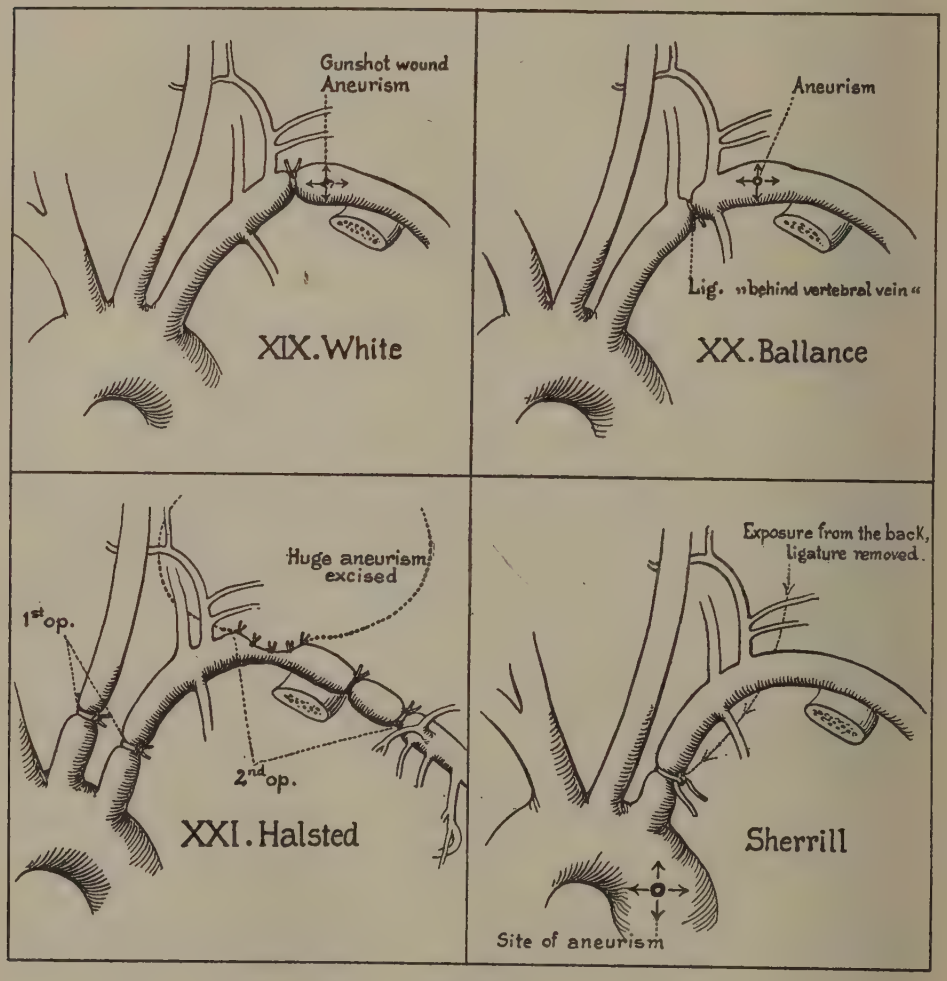
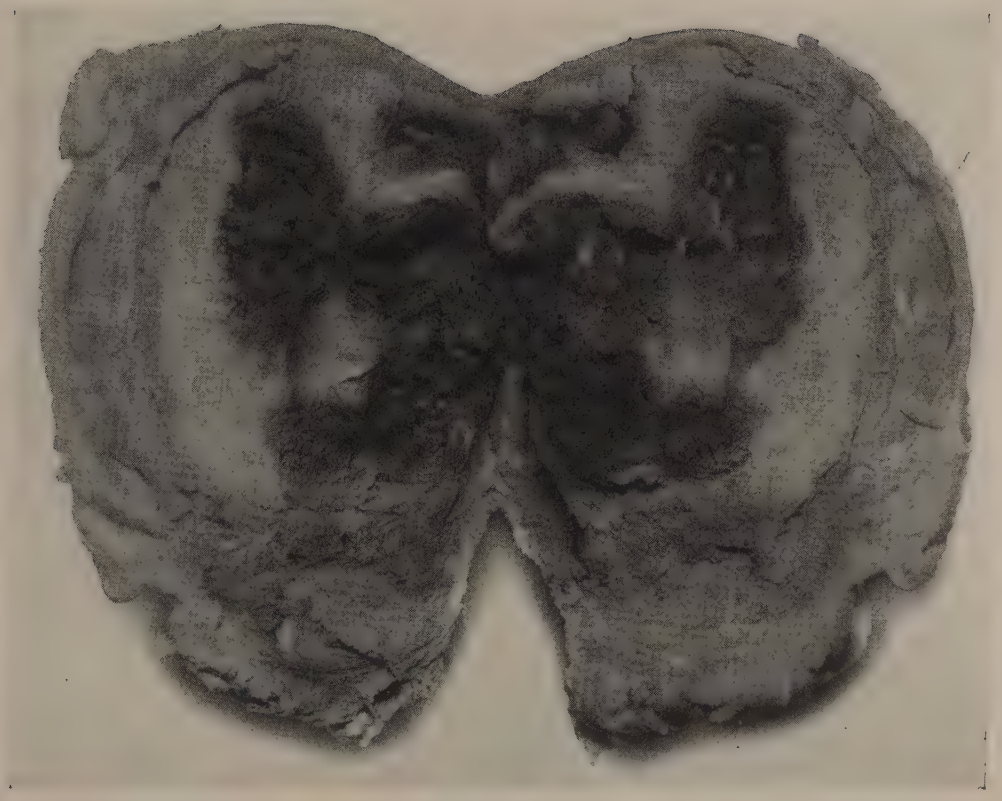


FIG. 56.

* We have placed the ligature of Ballance proximal to all the branches except the vertebral, although its precise location is doubtful. Ballance states that he tied the artery behind the vertebral vein. This vein, irregular in origin, is usually internal and anterior (Henle) to the artery in this part of its course.

† In Neff's patient the thyroid axis and the vertebral and internal mammary arteries were also tied. The exact position of the hole torn in the subclavian in this case was not determined and consequently may be erroneously indicated in our diagram.



The excised aneurism, bisected (Case No. XXI). The sac is filled with hyalin and compressed, laminated old clot, canalized at the periphery by the bloodstream.

In the dark, central areas the imbedded clots are younger and studded with cavities containing fluid blood. The specimen (actual size) is probably unique.

Purmann's operation (1680). "Anno 1680. habe ich zu Halberstadt eine Frau, Anna Peterin, gewesene Kretschmerin zu Langenstein, 38. Jahr alt, mit einem sehr grossen Anevrismate des lincken Armes in die Cur bekommen, damit die sich schon über. 3. Jahr geplaget; Die Grösse und Form zeiget beykommende Figur." Purmann, Chirurgia curiosa, ed. 1716, p. 612.

In no case, Stonham's excepted, was there restoration of the radial pulse after operation. In Stonham's patient it was equal on the two sides before operation and reappeared 24 hours after the ligation of the subclavian. The anastomotic circulation was presumably well established before the operation, for the reason, as stated above, that the presence of a cervical rib may be assumed.

Perusal of the original accounts of the cases of gangrene following ligation of the subclavian artery reveals the fact that in each instance there was a serious complication—thrombosis, arterio-venous fistula, ligation of the axillary artery, etc. I have failed to obtain any evidence that gangrene has been caused by the uncomplicated ligation or ligations of either subclavian artery.

In a paper by Bean[6] based upon 129 dissections by students of the subclavian and its branches recorded upon Bardeen's charts we find summarized the views of Quain, Testut, Gray, Henle, Tiedemann, Spalteholtz and Toldt, Sappey, and himself as to the normal origin of the branches of this artery on both sides of the body (*vid.* Fig. 57). The conclusions arrived at by Bean from his study of Bardeen's charts are as follows:

"I. The branches of the subclavian artery differ in their origin on the two sides of the body. . . . .

"(a) There is a tendency in the branches of the subclavian artery to bunch themselves in their origin on the left side, whereas on the right side there is a tendency in each branch to arise directly from the subclavian artery.

"(b) The thyroid axis, dividing into the suprascapular, transverse cervical, and inferior thyroid arteries, is not normal, except on the left side.

"(c) The transverse cervical artery and the costocervical trunk arise from the second part of the subclavian artery more frequently on the right side than on the left side.

"(d) The superficial cervical artery is of infrequent occurrence, and is found more often on the right side.

"(e) The transverse cervical artery terminates by dividing into ascending and descending rami, the latter being commonly called the posterior scapular artery. The former divides underneath the trapezius muscle and supplies the upper and middle part of the back.

"II. There are five important, and not infrequent, anomalies to which the attention is directed:

"(a) The origin of the right subclavian artery from the descending part of the aorta. This occurs 4-6-8 times in 1000 cases (0.5% to 1% of all persons).

"(b) Variableness in the origin of the transverse cervical artery, especially on the right side.

"(c) The presence of a middle thyroid artery (Thyroidea ima).

"(d) The suprascapular artery arising from the internal mammary artery.

"(e) The lateral thoracic artery arising from the internal mammary artery.

"III. Eighty per cent of the dissections were made in negro subjects, a large number of whom may have been mulattoes or mixed bloods. That hybrids tend toward variation is a recognized biological law. This may explain the unusually large number of abnormalities encountered.

"IV. Twenty-three infants were dissected and many of these show irregularities, particularly in the distribution of the suprascapular artery, which is frequently deficient, its place being taken by the dorsal scapular artery.

"V. The branches of the subclavian artery may be more numerous in adults than in infants. The branches rise from all parts of the artery in adults, whereas in infants the branches frequently rise in a bunch from Part I."

In choosing a diagram to represent the norm for the left side I have accepted the representations of Quain, Gray, Testut, and Bean. According to Bean, our diagram depicts correctly the norm for the left side—the side which at present concerns us—but not for the right side. Bean states that the arrangement shown in the diagram which I have adopted as typical was found by him in 55 per cent of the students' dissections of the left subclavian. For the right side the majority of anatomists give the origin of the arteria transversa colli to the third or second portion of the vessel (*vid.* Fig. 57).

The Treatment of Aneurisms of the Subclavian Artery

The six patients upon whom I have operated for aneurism of the subclavian artery recovered ideally without gangrene or added loss of function; the wounds, all closed without drain, healed *per primam,* and in all the aneurism was cured, but I am sure that in several instances the operative measures were not quite those I should under like circumstances practise today. For example, I should not again, as in my first case (V), excise the aneurism in an old man unless a proximal ligature had falled to cure it; and I believe that the excision of the aneurism in Case No. XXI should have been undertaken much earlier in order to liberate more promptly the matted nerves.

We can forecast with greater confidence than for the subclavian certain generalizations in regard to the treatment of aneurisms of the extremities situated so low that an elastic band or tourniquet may be satisfactorily applied above them. In such cases the sac should be opened and excised and a suture—lateral or end-to-end—be made, when feasible. The openings in the sac of the afferent and efferent ends of the artery may be only a few lines apart. Within the past 18 months Dr. Mont Reid (resident surgeon) of our staff at The Johns Hopkins Hospital has once made a lateral and

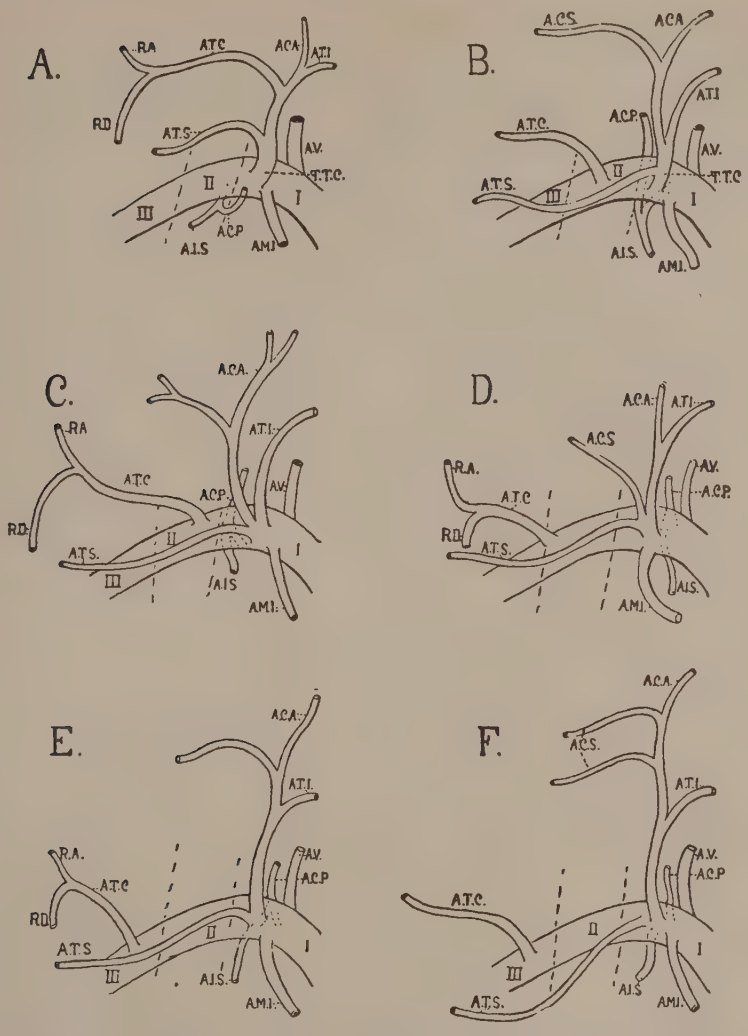


FIG. 57.—Branches of the subclavian artery according to different authors. *A*, according to Quain, Testut and Gray; *B*, according to Henle; *C*, according to Tiedemann; *D*, according to Spalteholz and Toldt (B. N. A.); *E*, according to Gegenbauer; *F*, according to Sappey.

The lettering on all the figures is alike and as follows: *I, II* and *III*, the three parts of the subclavian artery; *A. V.*, arteria vertebralis; *A. M. I.*, arteria mammaria interna; *T. T. C.*, truncus thyreocervicalis; *A. T. I.*, arteria thyroidea inferior; *A. T. S.*, arteria transversa scapula; *A. T. C.*, arteria transversa colli; *R. A. T. C.*, ramus ascendens transversa colli *R. D. T. C.*, ramus descendens transversa colli; *A. C. S.*, arteria cervicalis superficialis; *A. C. A.*, arteria cervicalis ascendens; *T. C. C.*, truncus costocervicalis; *A. I. S.*, arteria intercostalis suprema; *A. C. P.*, arteria cervicalis profunda; *C. T.*, common trunk.

twice an end-to-end suture in cases of aneurism of the popliteal artery. In each instance the pulse in the tibial arteries was immediately and permanently restored. If the artery has been ligated the operator must carefully observe the state of the circulation in the foot, making use of one or more of the several tests at his disposal. If there is reason to fear gangrene, he should note the effect of occlusion (temporary or permanent) of the corresponding vein. If gangrene still threatens, the interpolation of a piece of vein between the arterial ends is indicated and should be undertaken provided the surgeon has made himself proficient in the art of suturing blood vessels. It is clearly the duty of every surgeon to practise on animals the end-to-end suture of arteries until he has become master of the technique. To consider the proper procedures for surgeons of diverse degrees of qualification would involve us in a discussion too prolonged.

Agreed as to what the treatment should be of aneurisms of the extremities whose blood supply can usually be controlled, we may advance to the consideration of the extent to which these ideal procedures may be applicable to aneurisms in or above the groin and axilla—above, in other words, the domain of the tourniquet. It is clear, I think, that aneurisms of the neck and groin should not be incised until their arterial supply on all sides has been temporarily shut off. When a ligature can be applied between the proximal pole of the aneurism and the branches of the first and second portions of the subclavian artery and another beyond and close to the distal pole, the sac may, if there are indications for doing so, be safely opened, for in only a small percentage of the cases would a branch (the arteria transversalis colli) be a possible source of annoyance. If the aneurism is of one of the first two portions of the subclavian and the ligature has been applied proximal to the grouped branches it would always be troublesome and sometimes impossible to shut off its blood supply completely. It is fortunate, therefore, that such a large percentage of the aneurisms of the left subclavian have been cured merely by ligation of its first portion. An indication for immediate opening of the sac might be the paralysis due to pressure. In the majority of cases I should be inclined to test the effect of proximal, or proximal and distal, ligation. Should pulsation persist after the double (proximal and distal) ligation of the subclavian I should, when the wounds from the first operation were firmly healed, or sometime thereafter, excise the aneurism. Certainly one should not cut into a pulsating aneurism, and to search for and ligate all the branches of the first portion might be an undertaking more formidable than the excision of the sac; it might indeed be quite impossible to secure these tributaries without first dislodging the tumor. I should even hesitate to open a non-pulsating aneurism which had shown no tendency to decrease in size. If for any reason

a surgeon has decided to slice into an aneurism of the subclavian, my advice to him would be to free first by dissection as much of the tumor as possible and then split it widely to the deepest parts. An operator searching for a bleeding point in a pool of blood, and particularly so when embarrassed in his movements by the adherent walls of an aneurism within which he is working so disadvantageously, presents a distressing spectacle. I would rather devote an additional hour or more to an operation than be caught for a few moments in such a predicament.

Common errors in the treatment of aneurisms are the following: (1) opening the sac or pulsating haematoma without first making a temporary occlusion of all the possible sources of haemorrhage; (2) permanent ligation of a great arterial trunk as a precautionary measure in the search for a distal bleeding point; (3) ligation of a trunk too far from the aneurism; (4) stuffing the wound with gauze to arrest haemorrhage; (5) drainage; (6) the employment of catgut for the ligature, or of silk that is too fine; (7) ligation of the artery proximal to an arterio-venous aneurism or fistula.

May Gangrene be Prevented by Ligation of the Vein Corresponding to the Occluded Artery?

In 1906 von Oppel[43] and Korotkow made observations in the course of three operations in one day for the cure of arterio-venous fistula which are of fundamental importance in their bearing on the question of ligating the vein corresponding to the artery with the idea of preventing gangrene. Von Oppel's account of this experiment on the human subject, well worth preserving in the English language, is as follows:

"Male, aet. 32. Wounded in the left shoulder by a rifle ball. Entered hospital in St. Petersburg, April 26, 1905.

"*Diagnosis.*—Aneurysma arterio-venosum axillare; collateral arterial routes fairly developed.

"May 5, 1905. The first operation began at 11 o'clock in the morning and ended at 11.30. The incision was begun a finger-breadth above the border of the pectoralis major muscle and carried 7 cm. downwards. The N. cutaneus medius was drawn outwards, the vein exposed. Exactly in the neighborhood of the pulsating tumor two brachial veins emptied into the axillary vein. The latter was varicose immediately above the site of the junction. A rather thick collateral branch was given off from the inner of the two brachial veins. Wishing to abbreviate the intervention as much as possible I decided (1) to ligate the axillary artery above the aneurism; (2) to ligate the external brachial vein in order to retard the flow of the venous blood. I believed that the communication with the aneurismal sac was located in the varicose portion of the dilated vein. Without laying bare the aneurismal sac, I pushed the N. medianus and the axillary vein outwards and divided the axillary artery between ligatures.

"The operation was carried on without the application of an elastic bandage above the aneurism, hence Korotkow was able, immediately after the division of the artery, to measure the blood pressure in the fingers. To our surprise this was 0, and the extremity became pale. As I was sure from previous examinations that the collateral routes were sufficient and attributed the result of the measurement of the blood pressure to some accidental cause, I completely closed the wound and applied a dressing.

"However, although the extremity became warmer, the blood pressure did not rise. At 1.30 in the afternoon the arm was deathly pale, the blood pressure 0. On the volar surface of the thenar eminence there developed a bluish dark red oval spot. Immediately on regaining consciousness the patient began to complain of extraordinarily severe pains in the arm. The forearm and hand were insensitive and completely paralyzed (ischaemic paralysis), the cutaneous veins entirely collapsed—in a word, gangrene of the extremity was developing beneath our eyes.

"This state of affairs needed clarifying and the explanation which Korotkow gave was so convincing that I declared myself in full agreement with him. Korotkow reasoned as follows: Since the axillary vein above the aneurism and the axillary artery below the aneurism were not ligated, the arterial blood of the collateral routes was being carried off by the veins through the aneurismal sac. In order to remove this influence of the veins one should ligate the axillary artery above the aneurism.

"The second operation, likewise under chloroform narcosis, was begun, without elastic bandage, at 3.30 in the afternoon, and finished at 4.30 o'clock. The wound was opened, the axillary vein exposed above the aneurism and divided between ligatures. In spite of this the blood pressure remained 0. As the explanation given above in regard to the cause of the gangrene appeared to be irrefutable, one had, in seeking a reason for the lack of effect of the ligation of the axillary vein, to find it in the existence of some accessory veins which might carry away the blood from the aneurismal sac. Consequently, I began to search for accessory veins, whereupon quickly the evolution was as follows: Scarcely had I compressed with the finger the space between the stumps of the divided artery, when the forearm and hand immediately became red, and Korotkow, who uninterruptedly was measuring the blood pressure in the fingers, observed a rise in the blood pressure to 40 mm. I had hardly removed the finger when the blood pressure went back to 0, and the extremity again became pale.

"Considering these facts, I began to dissect the deeper parts of the axilla behind the artery and, in fact, found there an abnormally thick venous trunk. The size of this vein was not less than that of the axillary vein, which lay in front of the artery. This venous trunk—the V. axillaris profunda—was isolated, and divided between ligatures. The blood pressure in the fingers rose to 40 mm.; the extremity became red. Wound completely closed; aseptic dressing.

"When the dressing was about completed I noticed that the arm was again becoming pale. In putting on the dressings the arm had been held in the vertical position. When lowered, the arm reddened somewhat. The patient was put to bed, and to the arm, dependent, hot water bottles were applied.

"As the patient came to himself he again began to complain of severe pains; the blood pressure was falling fast. Although complete paralysis was not present, there were suggestions of beginning gangrene in the hand and forearm. The second operation had undoubtedly brought about an improvement in the circulation in the hand and forearm; but the improvement was not yet sufficient, and the danger of gangrene developing had not passed. At 7.30 in the evening the blood pressure in the fingers again sank to 0. When the arm was held up a high degree of bloodlessness ensued immediately; when lowered, it recolored barely if at all. Pains as before; the ischaemic paralysis increased.

"On account of the threatening symptoms I decided to operate again, to excise the aneurismal sac. We attributed the increase in the symptoms of beginning gangrene to the dilatation of the collateral venous routes, which again, through the efferent arterial trunk, took up the collateral blood by way of the aneurismal sac.

"Third operation under chloroform narcosis, without elastic bandage. Begun at 8.30 p. m., ended at 9.30 p. m. The lower half of the wound was opened, the incision lengthened downwards. Starting at the point above the sac where the artery and the veins were divided, I began gradually to dissect out the sac. The radial nerve, which was somewhat adherent to the sac, was freed. The sac itself had invaded the M. brachialis internus. During the dissection the sac was wounded and a feeble stream of arterial blood issued from it. This circumstance was the best evidence that the blood, actually streaming back out of the efferent arterial trunk, coursed into the aneurismal sac, to be carried out of it back to the heart by the veins. After the sac was excised it was found that several veins led out from it.

"Scarcely were the distal veins * ligated and the sac excised when the hand and the lower third of the forearm became very hyperaemic; the blood pressure in the fingers rose to 30 mm. Hg. The hyperaemia reminded one exactly of that which usually follows the removal of the elastic bandage; it was sharply circumscribed, on the dorsal surface of the forearm reaching to 13 cm. above the radio-carpal joint, and on the volar surface to 7 cm. above this joint. In addition, I would say that this hyperaemia lasted for 24 hours.†

"It was also clear that if the third operation had not been performed, it was exactly this hyperaemic region which would have broken down.

"Closure of the wound. Introduction of a strip of gauze into the lower angle of the wound. Aseptic dressing.

"At 11.30 p. m. the patient became conscious. No trace of the pains and paralysis remained. The pareses which were present before the opera-

* In the course of the excision of the sac the axillary artery must have been ligated both above and below the fistulous communication with it or, what amounts to the same things so far as the circulation is concerned, the arterial neck of the sac must have been tied. Thus the result of the three operations was excision of the aneurism with ligation of axillary artery and vein both above and below the sac and of other vessels encountered in the course of the dissection. (W. S. H.)

† May not the persistence of the hyperaemia be ascribed to the arterial sympathectomy? (W. S. H.)

tion and which were caused by the adhesion of the radial nerve to the aneurismal sac had likewise disappeared.

"Uneventful postoperative course. Temperature normal. Stitches removed on the 5th day. Healing throughout *per primam*. From out of the region of the tampon a moderate quantity of clear lymph issued for the first few days. On the day after operation the arterial pressure in the fingers rose to 40 mm. Over the gangrenous spot on the thenar eminence the necrotic, superficial skin came away. The patient was discharged entirely cured and in good health."

If the sac had been excised at the primary operation of von Oppel the result would have taught us nothing—an opportunity would have been lost. I wish to emphasize this fact in the hope that surgeons may bear always in mind the opportunities which they have daily at the operating table to strive for results which may be contributory to the advancement of their science.

The operating room is a laboratory for the surgeon.

Learning by the ordinary routine experiences of practice what might have been ascertained from experimentation on animals cost in the last war an appalling loss of life and limb.

The lesson taught by von Oppel and Korotkow seems to have been forgotten or overlooked even by the Germans, for no mention is made of it by either Sehrt [55] or Propping,[47] the first of the surgeons of Germany—one must conclude from their communications—to discuss in general terms the vascular balance and to advocate as a routine procedure the simultaneous ligation of the vein and artery:

Sehrt. "The outflow or better the sucking up of the venous blood may best be prevented by ligation of the veins. Everything which accelerates the sucking away of venous blood (activity of the heart, etc.) from an extremity robbed of its arterial supply must contribute to the death of the part deprived. Thus may be explained cases in which definite gangrene of a segment of an extremity has appeared some little time after the receipt of the injury and after the general condition and especially the heart's force had improved. Every one may well have seen such cases. Under certain circumstances a severely injured member may be carried over the most dangerous period by venous blockage."

Propping. "One sees, therefore, that my explanation of the possible cause of gangrene of a limb after ligation of an artery goes farther than Sehrt's. In place of the 'sucking away of the venous blood' I advance the idea of a disproportion between in- and out-flow—to a certain extent a disturbance of balance of these two factors *—in order to explain the insuffi-

* Stromeyer in his Handbuch der Chirurgie, 1844, p. 371, proposes: "In Fällen wo varicöse Beingeschwüre für die Erhaltung des Gliedes Gefahr drohen und die Operation der Varices nicht rathsam erscheint, glaube ich, dass man *durch Unterbindung der arteria cruralis das Gleichgewicht in der Zuleitung und dem erschwerten Abflusse des Blutes wieder herstellen könne.*"

cient filling of the capillary bed and the thereby conditioned derangement of the nutrition of the tissues."

At the Séance of July 4, 1917, of the Société de Chirurgie Professor Tuffier [80] gave his views on the subject of the ligation of the vein:

"We all know that the three arterial ligations which most often expose patients to grave dangers of disturbance are (1) those of the femoral trunk, (2) those of the carotid at its bifurcation, and (3) those of the popliteal artery in the lower half of the popliteal space. If I believe everything that I have seen of ligations since the beginning of this war, it is that the occlusion of the popliteal in its lower half causes most disasters; gangrene of the limb is very often a consequence of it.

"To lessen the chances of ischaemia or of the gangrene following ligatures in these regions, it has been advised to have recourse more often to lateral sutures in all cases where the nature of the lesions permitted it, and I fully share this opinion. There is a great advantage in having recourse to arterial sutures; they are less difficult to place than one believes.

"There is a practice to which I desire again to direct your attention in this connection; it is ligation of the corresponding healthy vein in all cases of ligation of the great vessels of the root of the limbs. This question, raised long ago, can find in actual occurrences some particularly suggestive statistics. There is first a fact which appears well demonstrated; it is that ligation of the vein and of the artery in the case of wounds of the two vessels does not increase the danger of ischaemia. Moreover, the statistics of the English army, which Sir George Makins has communicated to us, give in this connection the following ratios: Ligation of the artery alone is followed in a general way by gangrene in 40.2 per cent, whereas simultaneous ligation of the artery and of the vein under the same conditions gives 24.5 per cent; and I speak only of gangrene from ischaemia.

"The most marked difference is in connection with the popliteal; ligation of the artery alone in 24 cases gave favorable results in 58.33 per cent, and gangrene in 41.66 per cent. Simultaneous ligation of the artery and of the vein has given in 28 cases 22 favorable results and only six cases of gangrene."

The firm position taken by such an authority as Sir George Makins has greatly influenced the surgeons of England and France, and his advocacy of the procedure made it almost mandatory in these countries in the last years of the war to occlude the vein accompanying the ligated artery. The arguments, summarized in his most admirable book, "On Gunshot Injuries to the Blood-Vessels" [83] (1919) are as follows:

"In preparing a former contribution to the surgery of wounded arteries,* I was much struck by the observation that proximal ligature of the femoral artery in cases of arterio-venous aneurysm was followed in a large proportion of instances by gangrene of the limb, while excision of the implicated segments of both artery and vein gave consistently good results. An expla-

* "Bradshaw Lecture, 1913."

nation of this apparent inconsistency will be found below, as also further considerations which led me to conclude that when an artery needs to be tied, the satellite vein should be occluded also.

"It is to be regretted that John Hunter himself did not write the paper describing his operation of proximal ligature and the grounds upon which he was led to undertake it. In at least one of the cases described in the paper by Sir Everard Home,* possibly in the first three, both the femoral artery and vein were included in the ligature; in the fourth we are definitely told that the artery only was included. From that period onwards surgical opinion has been definitely to the effect that the greatest care should be taken, when occluding a main artery, to avoid all injury to the vein. In fact, every operation for the ligature of an artery has been so devised that the aneurysm needle is passed in a direction away from the vein in order to minimize the risk of injury to that vessel, not alone to avoid the technical inconvenience of immediate haemorrhage, but also with the definite object of preserving the venous circulation intact.

"Observation of a large number of coincident wounds of large arteries and veins has in no way endorsed the view that simultaneous occlusion of both artery and vein exercises any deleterious influence on the subsequent collateral arterial circulation and the vitality of the limb. In support of this statement a few examples illustrating the innocuous nature of operations for the occlusion of veins in general may be first given. Operations for the cure of varicose veins have demonstrated the ease with which a compensatory balance is attained when the blood is diverted from the larger channels. Occlusion of the internal jugular and other large venous trunks effected in order to prevent the diffusion of septic emboli has not given rise to obvious permanent trouble. As is well known also, occlusion even of the vena cava by surgical methods has been survived, and the capacity of the venous circulation to maintain itself by compensatory changes, which is seen when this vessel undergoes obstruction by thrombosis, is a familiar experience.

"In a very considerable proportion of gunshot injuries to large arterial trunks the neighboring vein is contused and becomes thrombosed, and this has not been shown to give rise to increased risk of gangrene of the limbs. Ligature of the common carotid artery together with the internal jugular vein *en masse* has been performed in cases of emergency without increased risk of the development of the cerebral anaemia and softening so often a consequence of ligature of the artery alone. Further, where simultaneous ligature of both artery and vein in other parts of the body has been obligatory on account of wounds of both vessels, untoward events have not been observed.

"Evidence exists, moreover, that under certain conditions simultaneous occlusion of both artery and vein is a preferable procedure. The first example, not an unmixed or simple one, may be sought in the results observed to follow the application of a single proximal ligature to the artery in cases of arterio-venous aneurysm or aneurysmal varices of the femoral vessels.

* "John Hunter's Works. Palmer's edition, vol. iii, p. 604."

In patients so treated during the South African War,* gangrene of the limb followed in more than 50 per cent of the cases. The frequency of this accident finds a simple explanation if we consider what actually results from the operation. The main vessel being occluded and the direct arterial pressure from behind being abolished, blood which has been carried by the arterial collaterals to the distal portion of the injured trunk, instead of passing to the peripheral circulation, takes the course of least resistance backwards into the vein through the arterio-venous communication, and thus the limb practically bleeds to death much in the same way as if the distal end of the wounded artery opened on the surface of the limb. Hence the comparative safety of removal of the communication *en masse* and occlusion of all four openings by ligature which has been confirmed by numerous operations during the present war.

"A more striking example is offered by the result of ligaturing the popliteal vein alone for the treatment of senile gangrene of the foot. W. A. Oppel,† ascribing the good results occasionally observed to follow arterio-venous anastomosis for the cure of this condition to control of the venous circulation and consequent rise in the blood pressure of the limb, was led to substitute simple occlusion of the popliteal vein to produce the same effects. In six cases thus treated the extremities were seen to recover not only their warmth and color without the development of oedema, but also a certain degree of hyperaemia of the feet and toes.

"On these and other grounds it must be admitted that the balance of the collateral circulation is likely to be more efficiently maintained if the vessels which carry it on more nearly correspond in size and consequent equality in the blood pressure and rate of flow. The elimination, in fact, of the capacious main vein is a real advantage, since this for the time affords a too ready channel of exit for the diminished arterial supply, as well as an undesirable reservoir for stagnation.

"These considerations have led me not only to regard obligatory simultaneous occlusion of a main artery and vein as a negligible factor in the risk of gangrene of a limb; but to hold further, that the procedure is preferable whether the vein be wounded or not; the result of the combined procedure being to maintain within the limb for a longer period the smaller amount of blood supplied by the collateral arterial circulation, and hence to improve the conditions necessary for the preservation of the vitality of the limb.‡

"M. van Kend tested the accuracy of the above conclusions as to the rise of blood pressure at the laboratory of the Ocean Ambulance at La Panne by some experiments on animals, and made the following remarks in his observations at the Inter-allied Conference of Surgeons held in Paris in May, 1917:

'In carrying out a series of experiments made with the object of determining the indications and the physiological basis for transfusion of blood, I have had the opportunity of measuring the blood pressure in limbs of which the main artery had been

* "Surgeon-General W. F. Stevenson, Report on the Surgical Cases noted in the South African War, 1899-1902."

† "Zentralblatt für Chirurgie, 1913, No. 31, p. 1241."

‡ "Hunterian Oration, Lancet, vol. i, 1917, Feb. 17, p. 249."

ligatured. The blood pressure was taken successively after the artery alone had been tied, and again when ligature of the vein had been superadded. My observations confirm the view that has been expressed by Sir George Makins; in fact, plethysmographic tracings demonstrate clearly that a slight rise in the blood pressure in the limb follows the application of a ligature to a main vein, after previous ligature of the artery.

'It appears, then, from the standpoint of the physiologist, that to leave the main vein viable after occlusion of the main artery of a limb, diminishes what may be called the *residuary blood pressure* maintained by the collateral circulation. If the contribution of the collateral circulation is allowed to remain with the main vein intact, it is natural that the *residuary blood pressure* should fall. If this view be adopted, ligature of the vein as well as the artery should be recommended in order to retain the blood supplied in longer contact with the tissues. Thus the most satisfactory conditions for the maintenance of the nutrition of the organs are provided, because the obstacle to the return circulation provided by ligature of the vein retains the blood for a longer period in the member.'

"After discussion of the question at the meeting, the following conclusion was adopted:

'Contrary to what has until now been believed, simultaneous ligature of both artery and vein when both vessels have been wounded does not give rise to increased risks of gangrene; in fact it diminishes them. Facts tend to prove, even when the wound is limited to the artery, that simultaneous occlusion of the unwounded vein is to be recommended.' *

"Major Hamilton Drummond has kindly furnished me with a note regarding some investigations which he made on this subject in the case of the visceral vessels. Loops of the small intestine of the cat, and of the colon of the Belgian hare, were made use of. After a careful study made by means of barium injections and X-ray photographs to determine the number of vessels which should be ligatured in order to avoid error from leaving too free an anastomotic supply, the following experiment was made six times on cats' intestine:

'A loop of ileum towards the caecal end was drawn out of the abdomen, and the arteries and veins supplying about five inches of the gut were ligatured, cutting off the total macroscopical blood supply to that portion. The loop was returned into the abdomen, and a second loop about six inches higher was delivered and devascularized by ligature of the artery alone.

'Of six experiments performed upon the cat, in three a definite ring of gangrene developed in the middle of the segment of bowel which had been deprived of its arterial supply alone, while the segment treated by simultaneous ligature of artery and vein showed little or no change. In one case where the animal was killed while still looking in good health, twenty-four hours after ligature of the vessels, the segment treated by ligature of the arteries only showed more serious changes than the segment treated by simultaneous ligature of artery and vein. Of the remaining two cases, one showed no change at all, consequent upon the fact that too short a segment of the bowel had been deprived of its blood supply, while the result in the sixth case was complicated by the development of an acute volvulus.'"

Dr. D. R. Hooker has very kindly tested for me in the dog the effect on the arterial blood pressure in the vessels of the leg of temporary occlusion of the external iliac vein after ligation of the corresponding artery, and sends me the following report: "The saphenous artery (a small branch of the femoral) was cannulated and the arterial pressure (femoral) recorded. When the external iliac artery was ligated the pressure promptly fell from

* "Comptes Rendus, Conf. Chir. Interall., Paris, 1917, p. 348."

114 to 26 mm. Hg. In the course of an hour the pressure rose to about 50 mm. Hg., but the point of interest lay in the response of this pressure to temporary occlusion of the external iliac vein, the chief arterial supply to the part remaining shut off. In six observations in the period of an hour in which the vein was occluded from one to eight minutes the arterial pressure rose 20, 12, 8, 3, 10, and 14 mm. Hg. Deocclusion of the vein was followed by a sudden fall in pressure and a subsequent slow rise. This rise, however, never reached the level established when the vein was occluded."

The necessity for maintaining a proper balance between the arterial and venous systems is suggested by the prompt diminution of the swelling of the limb on ligation of the artery feeding the pulsating tumor. In the case of a very large ilio-femoral aneurism the swelling of the thigh and leg rapidly subsided after a partially occluding band had been applied by me to the external iliac artery. Three or four weeks after the application of the band the aneurism and the deep and superficial femoral veins were excised. These veins were found to be completely occluded by the tumor; hence the reduction in swelling which promptly followed the ligation of the artery could not have been due to relief of pressure on these veins. The operation was performed about five years ago. The patient, a stevedore, writes that the function of the limb is perfect. In striking contrast to this is the result obtained in another patient whose common iliac artery I ligated, many years ago, but not the corresponding vein. In this instance the patient was prevented by claudication from ever walking more than one or two hundred yards.

We are compelled, I believe, to subscribe to the view that some degree of equilibrium of the arterial and venous systems must be maintained. Granting this, there vanishes any difficulty that there may have been in accounting for the very high percentage of gangrene observed to follow ligation of the artery in cases of arterio-venous fistula. There is in these cases not only a great enlargement of the venous bed but also a curtailment of the arterial tubage—a shrinkage or hypoplasia of the arteries distal to the fistula. Thus even before the artery is ligated the limb is handicapped by this lack of balance. When, now, the artery above a fistula is tied, irrigation with arterial blood is suppressed on one side of the capillary bed and on the other side of it the mixed blood is deprived of a share of the pressure by virtue of which the life of the limb was partly sustained. It seems permissible to conjecture that in some instances the limb distal to the fistula may have been hardly less dependent on the pressure from the venous than from the arterial side, and if so we can more readily comprehend the ensuing gangrene than the frequent absence of it after ligation of the fistuled artery. The gangrene, almost unprecedented in extent, which followed the remarkably

brilliant operation of Matas [35] for the cure of a fistula of the subclavian vessels was undoubtedly intensified by the fact that this skilful surgeon succeeded, by careful suturing, in preserving the lumen of the vein.

The reversed picture of disbalance—the obturated vein with the patulous artery—is a more familiar one.

Ultimately we may be less disinclined to ligate arteries for the relief of swelling due to occluded veins—veins plugged by carcinoma or thrombus. Our thoughts revert to the important contribution of Carnochan [9] who cured a case of elephantiasis Arabum by ligation of the femoral artery, and to the unpublished experimental work of Welch and Mall * on intestinal infarction.

Since ligation of the vein raises the blood pressure in the ischaemic area, is it not possible that the response of the arterial side for anastomotic development may be delayed or lessened for a period and to a degree conformable to the time and amount that the obstruction of the vein contributes to the maintenance of the circulation of the extremity? If this is so, might not the ligation of the like-named vein be postponed, when this can be done without danger, in order not to relieve the arterial side of its responsibility? Then if after a time there should be evidence of disability from ischaemia, such as claudication on exercise, the surgeon would have the ideal opportunity to demonstrate the value of the venous ligation.

Another possible expedient is to be borne in mind. A metal band (aluminum) might be applied temporarily to the vein. The pressure within veins is so slight that a band might, perhaps, without producing necrosis as of an artery, be tolerated for weeks or months or indefinitely.† I suggest this as an experiment which might help to solve the problem; but first we must determine how long a totally and how long a partially occluding band may remain on the wall of a vein without bringing about its permanent obturation.

* This paper will be included in "Papers and Addresses by William Henry Welch," 1920, being published by The Johns Hopkins Press. [*This publication has appeared.*—Editor.]

† A few years ago Dr. Reid and I, at his suggestion, applied an aluminum band to the pulmonary artery of a dog, reducing the lumen of this vessel by about one-half. Eighteen months later the dog, in good health, was sacrificed. The wall of the pulmonary artery was found to be nearly intact; only at one point on its proximal edge had the band perforated the wall of the vessel. The lungs were apparently unaffected by the diminished supply of blood.

About ten years ago, with Dr. James F. Mitchell of Washington, I partially occluded with an aluminum band an enormously dilated ilio-femoral vein, above an arteriovenous fistula, after a prolonged attempt on the part of both of us to dissect free the involved vessels. Only slight relief was afforded by the constriction of the vein; and the desperate condition of the patient precluded further intervention.

Gangrene has so rarely followed ligation of the subclavian and common iliac * arteries that in the case of these vessels I should for the present be disinclined to tie off simultaneously the corresponding vein.

Abstracts of the Cases of Ligation of the First Portion of the Left Subclavian Artery. Comments

J. Kearny Rodgers. (1.) *Case of ligature of the left subclavian artery within the scalenus muscle, for aneurism.* New York Journal of Medicine and the Collateral Sciences, 1846, vii, 219.

"Michael Larman, born in Germany, aged 42 years, was admitted under my care, into the New York Hospital, September 13, 1845, with aneurism of the left subclavian artery. The account he gives of it is as follows:

'About four weeks ago, when carrying a basket of peaches (containing about a bushel) on his left shoulder, he was suddenly seized with a severe pain in the shoulder and arm, and was obliged to lay down the basket. On examining the part, he then, for the first time, observed a swelling above the clavicle, about the size of a pullet's egg. Since last winter, about February, he had suffered pain in the arm, and observed that it was occasionally swollen; but was not obliged to give up work.'

"On examination, a pulsating tumor can be seen above the left clavicle, about the size of a small hen's egg, rising beyond the bone about two inches; extending externally to the outer third of the clavicle, and internally, covered by the outer edge of the sterno-mastoid muscle. Pulsation was very distinct over the entire surface of the tumor. The cutaneous veins below the sternal end of the clavicle were very much enlarged and their coats thickened. There were marks of cupping over the shoulder.

"The patient complains of severe pains in the axilla, extending down the arm to the finger ends. He cannot sleep, and his general health has suffered from the want of rest, being obliged to walk his room at night on account of the severe pain; the left arm and hand are swollen, so as to interfere with the flexion of the fingers.

"There was no perceptible difference in the pulse at the wrists. Its beat was 92, soft and full. . . . .

"*September 28, 1845.*—A consultation of the surgeons being called, they, after a full discussion of the case, very kindly left it with me to decide whether the operation should be performed.

"The tumor continued slowly and gradually to increase, and passed more under the mastoid muscle than on his admission, so as to give me some apprehension of trouble from it in the operation.

* It is still believed (Wolff,[63] Matas,[36] and others) that ligation of the common iliac artery is followed by gangrene in from 33 to 50 per cent of the cases. That this belief is erroneous is proved by my careful study of each reported case. On page 215 of my paper[21] is the following statement: "Granted that in the cases of Lange and Cranwell the ligation of the artery was solely responsible for the gangrene, we have only two such cases in the thirty of my collection, a percentage of six and six-tenths. If it should appear later that Cranwell's case might, for unascertained reasons, be excluded, the percentage would be three and three-tenths, and the sum total of gangrene the cutaneous necrosis of one toe."

"He was apprised of the fatal nature of the disease, and the dangers of an operation, but his sufferings were so great that he expressed his willingness to undergo whatever operation afforded the least prospect of relief from pain and of restoration to health.

"Having decided on tying the subclavian artery, I summoned my colleagues on the 14th of October, and the operation was performed in the theatre of the hospital at 1 p. m. of that day, in the presence of Drs. Mott and Stevens, consulting surgeons, of Drs. Cheesman, Post, Hoffman, Buck, and Watson, surgeons, and an assemblage of about three hundred physicians and students.

"The patient was laid on a low bed, with his head and shoulders raised, and his face turned to the right side. The light from the dome shone directly on the part to be operated on.

"An incision was made three inches and a half in length on the inner edge of the mastoid, terminating at the sternum, and dividing the integuments and platysma myoides. This was met by another extending along the sternal extremity of the clavicle, about two and a half inches. This last incision divided a plexus of varicose veins passing in the integuments, covering the clavicle to the subclavian. Free bleeding taking place from their cut and patulous extremities, it became necessary to check it by ligature.

"The flap of integuments and platysma myoides was now dissected up, and the lower end of the mastoid laid bare; a director was passed under this muscle, and the sternal portion and half of the clavicular divided by the bistoury. This muscle was now turned up, and the sterno-hyoideus muscle, the omo-hyoideus, and the deep-seated jugular vein were seen covered by the fascia.

"On turning up the mastoid, a portion of the aneurismal sac strongly pulsating was brought into view, overlapping about half the width of the scalenus, forming now the outer part of the track through which I was to pass, showing fearfully one of the dangers of the operation, which, from my previous examination of the part, I had of course anticipated.

"The fascia being divided by the handle of the scalpel and the fingers, I passed in contact with the deep jugular on its outer side to the inner edge of the scalenus anticus, intending, for the purpose of avoiding as much as possible all danger to the thoracic duct, to reach this muscle fully half an inch above the rib, rather than at its insertion. I now felt distinctly the phrenic nerve running down on the anterior surface of the scalenus, and was confident that I should be able to avoid any injury to it. Having attained the inner edge of the scalenus, by pressing downwards with the finger, I soon discovered the rib, and after some little search easily found the subclavian artery. By pressing it against the rib, all pulsation ceased in the tumor, and by removing the finger, pulsation returned.

"I now felt that great care was necessary to detach the artery, and avoid danger to the pleura and thoracic duct. In accomplishing this part of the operation, I at first tried Sir Philip Crampton's instrument, but ascertaining that I could better carry the ligature around the artery and bring up its end, by the invention of Drs. Parrish, Hewson, and Hartshorne, of Phila-

delphia (long since given to the profession by them, and lately claimed by Mr. l'Estrange of Dublin), I accordingly adopted that instrument.

"This part of the operation it will be imagined was not very readily accomplished. The great depth of the vessel (nearly the length of my forefinger), and narrowness of the wound, prevented a very easy management of instruments. The point was introduced under the artery, and soon directed upwards so as to avoid injury to the pleura. The needle carrying the ligature was now detached from the shaft of the instrument, and drawn upwards so as to include the artery. I readily tied the ligature, and tightened it with the forefingers in the bottom of the wound. All pulsation immediately ceased in the aneurism and the arteries of the extremity.

"The patient complained of no pain or unusual feeling in the head, as might have been expected from so suddenly changing the current of so large a quantity of blood. . . . .

"6th day, October 19th. . . . . wound suppurating; its sutures were removed; . . . . poultice to the wound. . . . .

"9th day, October 22d. . . . . wound doing well, and suppurating freely. . . . .

"13th day, October 26th.—2 a. m. The patient, on changing his position from the right side to his back, felt a trickling down his chest of what he supposed was matter, but which the nurse ascertained to be blood. The house surgeon was immediately called, and controlled the haemorrhage by filling the wound with layers of dry hard sponge, placing a compress over this, and securing the whole by a bandage. About 20 ounces of blood were lost. . . . .

"14th day, October 27th.—6 a. m. There has been no bleeding during the night; pressure has been firmly made over the wound; the blood has passed under the integuments of the neck in so great quantity that there is a decided bulging of the skin on the left side, extending to the back of the shoulder. . . . .

"15th day, October 28th.—6 a. m. . . . . On removing the outer sponge there is a firm clot seen which for a time controls the bleeding, but the least effort causes a free gush of blood; gentle pressure to be continued. 1 p. m. The clot beneath the integuments causes so much pressure on the oesophagus as nearly to prevent deglutition; the tendency to external haemorrhage is less, and the external clot firm; there is danger that the blood effused may press on the larynx sufficiently to prevent respiration, and the pressure was accordingly discontinued; oozing continues. 5 p. m. Patient dying; no external haemorrhage. 5¼. Died.

"*Postmortem Examination, Eighteen Hours After Death.*—The wound was filled with coagula and sponge, which had been introduced for the purpose of making pressure. The blood was already in a state of partial decomposition. The dissection was carefully performed, exposing the different layers of muscles. The lower incisions made at the operation were found to include three-fourths of the mastoid, leaving a small portion of the clavicular portion undivided. Below this the aneurismal sac and the scalenus anticus formed the outer and posterior wall of the wound. The inner wall was formed of condensed cellular tissue covering the carotid artery, jugular vein, thoracic duct, and the edges of the thyroid muscle. At the bottom was

the subclavian artery, completely divided by the ligature, which was found free in the coagula. The cellular tissue of all the parts around the wound was condensed by adhesive inflammation, rendering the dissection exceedingly tedious and difficult. The jugular vein, which skirted the inner wall of the wound, was obliterated and filled with fibrinous coagula. Opposite the track of the ligature the vein was contracted to a cord, and impervious as far as its junction with the subclavian. The vena innominata and subclavian were normal. The pleura at the bottom of the wound presented a large irregular lacerated opening, communicating from the wound with the left pleural cavity, which was filled with coagulated blood. This formed one large uniform coagulum, and had every appearance of being of rapid and recent formation; the membrane around these was thickened. On exposing and tracing the subclavian artery, it was found that the ligature had been applied about one and a quarter inches from its origin at the aorta, and immediately at the root of the vertebral, on its cardiac side. The artery had been completely divided by the ligature, which as mentioned above was found loose in the wound. The stump of the subclavian, between the aorta and ligature, presented the appearance of a round solid cord, about an inch and a quarter long, and impervious to liquids or air. The external coat of the stump was thickened and adherent near the ligature to the surrounding tissues, by adhesive inflammation. On laying open the vessel longitudinally it was found that a firm fibrinous coagulum occupied the vessel, and was adherent firmly to its inner coat for three quarters of an inch; near the aorta, the coagulum was softer. The coats of the vessel were moderately thickened, and presented a small patch of atheromatous deposit about a third of an inch from the tied end. Around this deposit the adhesion seemed as perfect as at any other part. Beyond the ligature the vessel presented a different appearance. No plug other than a soft coagulum of blood occupied its cavity, and it presented much less evidence of adhesive inflammatory process in its coats. The vertebral was given off immediately at the point of ligature, and was open, containing a thin blood coagulum like the one in the subclavian. These were drawn out with ease, and evidently had formed during the last moments of life. About one third of an inch from the vertebral came off the thyroid axis, and nearly opposite the vertebral was the internal mammary. These vessels were all patulous and healthy. About half an inch from the thyroid axis commenced the dilatation of the artery to form the aneurismal sac. This tumor was about the size of a small orange, and had involved in its growth part of the scalenus anticus, the cervical nerves going to form the cervical plexus, the surrounding cellular tissue, and the glands. The aneurism was completely blocked up with coagula, and the axillary artery which emerged from its distal side was plugged with a fibrinous clot exactly similar to the one in the stump of the subclavian, though perhaps not so perfect. It appeared sufficiently so, however, to obliterate entirely the calibre of the vessel. The plug extended some distance down the axillary artery. The thoracic duct, which had been injected with wax from the abdomen, was found uninjured. The aorta was thickened, and its coats irregular from a considerable deposit of atheromatous matter in its tissues. The heart was somewhat larger than natural, but apparently sound. The other organs were not examined, as the friends insisted on an early removal of the body for burial.

"Although a decided majority of the consultation agreed as to the propriety of the operation of securing the artery for aneurism, still, as my colleagues kindly left it with me to decide whether it should be undertaken, I felt it incumbent on me to investigate the subject with great care, and accordingly gave it my most sedulous attention. I was the more anxious, because, in the only case in which the attempt had been made by Sir Astley Cooper, in 1809, that eminent surgeon failed of securing the vessel, and is said to have entertained apprehensions that he had wounded the thoracic duct.

"I had always considered it as a perfectly justifiable operation, and one that a careful surgeon conversant with anatomy could accomplish, if the tumor were of a moderate size.

"The want of success in the four or five operations on the right subclavian in its first stage did not discourage me, nor did they alter my opinion. The difference in the anatomy of the right and left arteries was so very great, that I did not consider it fair to argue that a similar result was to follow on the left side. The greater depth of the left, indeed, rendered the operation more formidable, but, if accomplished, not less likely to succeed.

"The point where the ligature must necessarily be applied on the right side is but a quarter or at most half an inch from the innominata and the coming off of the carotid; so that it could scarcely be expected that a coagulum would form sufficiently firm to adhere to the vessel, and resist the force of the heart's action. Besides, too, the greater force of the circulation on the right side was additionally unfavorable to success on that vessel, and, therefore, is an additional reason for distrusting an argument drawn from a parallel between the two.

"In examining anatomical and surgical authorities I found the opinion prevalent among almost all British authors that the operation on the left side was 'impracticable.'

"Colles, the eminent Irish surgeon who first tied the right subclavian in its first stage, says:

'This operation, difficult on the right, must be deemed impracticable on the left subclavian. For the great depth from the surface at which this vessel is placed—the direct course which it runs in ascending to the top of the pleura—the sudden descent which it makes from this to sink under the protection of the clavicle, and the danger of including in the same ligature the eighth pair of nerves, the internal jugular vein or the carotid, which all run close to, and nearly parallel with, this artery; these all constitute such a combination of difficulties as must deter the most enterprising surgeon from undertaking this operation on the left side.'—Edinburgh Med. and Surg. Journal, Jan. 7, 1815, p. 23.

"Harrison,* Flood,† Guthrie,‡ and Quain,§ all coincide in this opinion.

"The opinions of those eminent anatomists and surgeons being so decidedly against the *possibility* of the operation, it was only left for me to examine with great care the surgical anatomy of this vessel.

* "Harrison on the Anatomy of the Arteries. Dublin: 1833. vol. i, p. 125."

† "Flood. The Surgical Anatomy of the Arteries. London: 1839, p. 84."

‡ "C. J. Guthrie on the Diseases and Injuries of the Arteries, etc. London. 1830, p. 396."

§ "Quain's Anatomy, 3d edition. London: p. 492."

"Having had the thoracic duct injected with wax, I repeatedly dissected the parts concerned, and operated in every way that suggested itself to me as likely to present any advantages. My opinion of its feasibility was thus confirmed, and having never entertained any doubts of its propriety, I accordingly undertook it.

"I regret, indeed, deeply, the death of my patient, but the appearances presented on examination after death, have only strengthened the opinion I had previously formed, and have encouraged me to undertake it with some slight variations, should another case ever present itself.

"It has often happened with important operations that many of the first cases have been unsuccessful, while the carefully noted observations made on dissection have led to different modes of operating, and more uniform success.

"Previously to the performance of this operation many entertained doubts whether the force of the circulation so near the heart in so large a vessel would not prevent the formation of a coagulum, and of course interfere with the obliteration of the vessel.

"These doubts have now been removed, and I consider that all reasonable objections fall with them, except those arising from the anatomy.

"Danger to the thoracic duct and pleura are in my opinion the most serious of these, for, with ordinary coolness and care, there will be little danger of including the pneumogastric and phrenic nerves, or carotid artery, in the ligature. The veins may be lacerated by great roughness, but can scarcely be included.

"The thoracic duct, I think, can almost always be avoided by reaching the inner edge of the scalenus half or three quarters of an inch above its insertion, and then pressing the finger down towards the rib. The duct is thus kept out of the way of laceration by the finger, and afterwards by the aneurismal needle. I am aware that this duct varies in its course, but this direction I am confident will usually secure its safety. By adopting it in the many times I operated and dissected the parts in the dead body, it was uninjured.

"The artery lies in contact with the pleura, the laceration of which might be attended with very distressing and dangerous consequences. A careful introduction of the aneurismal needle, and soon turning up its point, will usually secure the safety of this membrane. In none of my operations on the dead body, where it was performed in this way, was it injured.

"The haemorrhage in this case came from the distal end of the artery, and the very free and direct anastomosis of the internal carotid at the base of the brain with the vertebral induce me to think that it was the latter vessel which transmitted the blood. Some indeed may have come through the thyroid axis, but I consider the former mode more direct.

"Should this operation be repeated, I would suggest the securing of the vertebral, and if possible the thyroid axis, by ligature. The difficulties are indeed thus increased, but not insurmountable.

"I present this case to the profession with the confident hope that they will give it their approval. I do not covet the empty honor of performing for the first time, be it ever so skilfully, any operation, however bold and difficult, but of doing that which, though once unsuccessful, will, from the

knowledge thence derived, enable us to enlarge our sphere of usefulness, and be the means of preserving human life."

V. Marchesano. (II.) *Legatura della succlavia sinistra fra la trachea e gli scaleni. L'Osservatore Medico, Palermo,* 1875, vol. v, p. 327.

"On the evening of July 17, 1875, a carpenter, aet. 34, presented himself at the Ospedale di S. Francesco.

"He was covered with bloody old clothes, and with his right hand pressed a wound which he had received a few moments before in the left side of the neck. The wound, he said, had been made by a blow from a chisel; it was immediately followed by abundant haemorrhage which was partly or entirely controlled by the hand of the wounded man himself so that he could be carried to the hospital. Having arrived there, the ward surgeon found a freely bleeding wound in the left supraclavicular triangle.

"This wound was about 4 or 5 cm. from the superior border of the clavicle, and 2 cm. from the posterior border of the sternomastoid.

"The surgeon of the ward dilated the wound with the intention of practising direct ligature, but not having succeeded, he made compression, and in view of the gravity of the case sent for the head surgeons of the hospital.

"I was the first to arrive, and from the quantity of blood which accompanied the discontinuance of the compression concluded that we had to contend with a haemorrhage proceeding from one of the superior branches of the subclavian, and probably of the posterior scapular.

"The wound was very deep; the finger of the observer did not fall on the bony plane formed by the anterior part of the cervical portion of the vertebral column, but ran along the transverse processes of the vertebrae. By pressing on the posterior face of these apophyses I could so hook the finger as to arrest the haemorrhage because in this attitude compression was exerted from without inwards upon the muscles which are inserted in the transverse processes. The blood came out through the fibres of these muscles, not in a direct jet as when a wounded artery is laid bare, but 'a nappo,' as if the jet, before coming into view, had encountered an obstacle.

"Considering the serious predicament in which one would surely find oneself in case it were not possible by the direct means to arrest this haemorrhage, I decided that it was justifiable to have recourse to any method which might be of service; I therefore practised anew the dilatation of the wound, with the object of discovering definitely the vessel from which the blood came and in order to be able to manoeuvre with greater ease; but in spite of this dilatation it was impossible for me to discover and seize the wounded vessel or even to grasp it by the inclusion of tissues.

"I had manoeuvred for about 20 minutes, when Prof. Errico Albanese happened in, who for about the same period of time repeated the same manoeuvre with the same lack of success. As the patient had already lost much blood, we agreed to make use of a tampon of cotton saturated with perchloride of iron, combining by this procedure the effects of compression and of a styptic. But although applied with the greatest care, the tampon did not check the haemorrhage even for a moment, hence it was necessary, in order that we should not see the patient die beneath our eyes, to decide

to ligate the subclavian between the trachea and the scaleni. I adopted the process used by Mott for ligating the innominate, which consists, as you know, in making two incisions which join at an angle in the neck, one of which runs along the internal border of the sternomastoid muscle for a distance of 5 cm., and the other over the clavicle as far as the clavicular insertion of this muscle, and in incising finally the sternal portion of the sternomastoid, the middle cervical aponeuroses, and the tracheal muscles, thus reaching the artery. Therefore, since it is my principle to avail myself of all possible means in carrying out an operation, and since it was a case of ligating the left subclavian in the first portion, at night and by artificial light, and since we had to manoeuvre in the vicinity of vital organs such as the internal jugular vein, the subclavian vein, the pneumogastric nerve, and the common carotid, I made the transverse incision longer than is prescribed by Mott, dividing a good part of the clavicular portion of the sternomastoid, the tracheal muscles, and more than the internal half of the scalenus anticus.

"At the moment when I cut the fibres of the scalenus anticus, I had Dr. Perni draw aside the phrenic nerve with a blunt hook. Opening the sheath of the artery I pushed as far inwards as I could the Cooper needle armed with a ligature.

"Assured that the tightening of the ligature controlled the haemorrhage, the direct compression which had been practised during the operation was released and the ligature tied. The operation was accomplished without serious accident.

"*July 18, 1875.*—The temperature of the left arm was the same as that of the rest of the body. July 24, 1875: In the middle of the night there was a haemorrhage, which was controlled by tampon and compression. Two hours later another haemorrhage occurred, which was controlled by the same means. July 25, 1875: Another haemorrhage, this time very serious. Compression and perchloride controlled this also. The patient was menaced with syncope. On July 30th there was noticed a small collection of purulent matter in the superior third of the internal region of the arm. A small incision was made, also lavage with disinfectants. On August 6, 1875, the patient's condition seemed to be fair and the wound of good aspect, but during the night at 2.30 a. m. there suddenly occurred a tremendous haemorrhage from the site of the ligature, and in a few moments the patient died.

"*Autopsy.*—The ligature had been applied 40 mm. from the arch of the aorta, exactly at the point where the subclavian artery departs from the vertical direction to turn outwards. The vertebral artery arose 7 mm. inside of the point of ligature, and immediately behind thise arose the ascending cervical with an independent origin; 5 mm. inside of the ligature the inferior thyroid arose. All the other arteries springing from the subclavian arose distal to the ligature. The two scapulars, the superior and the posterior, arose from a common trunk, which, situated 3 mm. outside of the ligature, after a course of 23 mm. running from in front towards the back and crossing the nerves of the brachial plexus, bifurcated and gave rise to them. This trunk was intact, but the posterior scapular was cut 6 mm. from its origin. The origins of the left subclavian and the left common carotid were 1 cm. apart. The ligature at the site of the ligation was not found; perhaps it had been removed with the débris in the dressings in the hurried

examination which I made of the cadaver. At the point of ligation the artery was completely cut through in jagged fashion."

L. C. Lane. (III.) *Ligations done for the cure of aneurism.* Pacific Medical and Surgical Journal, San Francisco, 1883-84, vol. xxvi, p. 145.

Page 149. "*Subclavian Artery.*—1. An engineer from a Sandwich Island plantation was brought from the Islands in an ambulance litter, afflicted with aneurism involving the termination of the left subclavian and the entirety of the axillary artery. The tumor, large as a fetal head, had apparently only the cutis for external wall. Through a quadrangular cut, the flap being attached above, the subclavian was reached in its trans-scalene site, and tied close to the muscle. Ligature was of small silk, carbolized, ends cut short and wound closed. The wound healed in two weeks and recovery was complete in two months. Today, eighteen months after the ligation, the man writes that the tumor has disappeared, his arm is restored, and he is doing his work as an engineer."

Although the ligation in this instance quite surely was not of the first portion of the artery, the quotation from Dr. Lane's brief report is given because it supplies the missing details of the first operation performed in the second case. Reciprocally, the description of the second operation in the second case makes it quite clear that Lane did not ligate the first portion of the subclavian in the first of his two cases.

"2. A miner from Alaska, with similar aneurism, though one-third less in volume, had the left subclavian ligated similarly,* except that the vessel was reached through a vertical cut. In one week, primary union of the wound. The man, of obstinate temper, near the end of the second week, though cautioned to maintain quiet, rose from his bed and used the close stool. A slight bleeding ensued through the reopened wound; later, another violent bleeding occurred. On the fourteenth day the wound was opened, and, while the blood that gushed from the distal end was controlled by sponge used as a tampon, the artery was exposed by severing the sternal leg of the sternocleidomastoid muscle, and a thread thrown around the subclavian just as it emerges from the thorax. This so arrested bleeding that a ligature was passed around the vessel close to the aneurism on the proximal side. Though there was no more haemorrhage, and the vitality of the arm was well maintained, yet the man died from exhaustion on the 19th day after the first ligation. It should have been remarked that before this man came under my care, there had been made an unsuccessful attempt to cure him by indirect compression digitally applied, at the point where ligation was afterwards done."

If the left subclavian was ligated by this "thread thrown around" it "just as it emerges from the thorax," Lane was the first to ligate the first part of this artery for the arrest of haemorrhage. If the thread was merely

* Between the scaleni muscle (*vid.* Case 1).

a provisional loop and not tied, then we should not credit him with a ligation of the left subclavian in its first portion.

Undoubtedly the haemorrhage took place from the subclavian at the site of the original ligature and, if so, two ligatures must have been applied at the second operation, the one, as Lane says, proximal and close to the aneurism, the other probably being the "thread thrown around the subclavian just as it emerges from the thorax."

Inasmuch as the two ligatures applied at the second operation (one proximal to the branches of the first portion, the other to the third portion, proximal and close to the axillary aneurism) controlled the haemorrhage, we must conclude that the bleeding occurred only from the distal end of the artery divided or at least cut into by the original ligature; for had the proximal end been open, the haemorrhage would not have been checked by the ligature "thrown around" the subclavian just at its point of emergence from the thorax, nor would the two ligatures applied at the second operation have sufficed; it would have been necessary to close the central stump of the artery cut through by the primary ligature.

It would not have been surprising if the result in Lane's first case had been disastrous, as it was in the second, for he tied the artery with "small" silk. Many times have I warned against the use of a fine thread of any kind for the ligation of large arteries, particularly for ligation in continuity. The danger from this we have had opportunities to observe in the course of our experiments on dogs. The fatal result in Lane's second case may have been due primarily to the fineness of the silk. This was quite surely the cause of the haemorrhage if infection can be excluded. But infection may well have played a part from the outset notwithstanding the fact that the wound is believed to have healed *per primam*. The act of getting out of bed, to which the surgeon attributes the haemorrhage, could hardly have been the only or even the chief factor in bringing about the fatal result.

Bernard Bardenheuer. (IV.) *Die Verletzungen der oberen Extremitäten.* Deutsche Chirurgie, Stuttgart, 1886, Lieferung 63a, Theil I, p. 445.

"Heinrich Grenberg, 47 years old, had a very large hard tumor in the left supraclavicular fossa. I pronounced it to be a carcinoma having origin in the internal jugular vein. The tumor extended inwards to the central plane, the larynx was pushed far to the right; above, the tumor was one inch removed from the mastoid process, outside, it came in contact with the outer border of the trapezius, and below, it disappeared behind the clavicle, or, rather, the manubrium sterni; it was *in toto* rather freely movable on the underlying parts. Above the tumor one felt the pulsating common carotid, likewise the radial artery pulsating synchronously and in equal strength with the coresponding vessel of the other side. There was no oedema of the

arm. Behind the clavicle one heard vesicular breathing. The mobility of the tumor, the presence of pulsation in the common carotid above the tumor, the presence of pulsation in the radial artery, the absence of disturbance on the part of the brachial plexus, led me to the opinion that a cure of the tumor might be effected without wounding one of the vital organs; tentatively, I proposed to ligate the arteries centrally. I did not fear to wound the pleura—which I knew was possible—after my own experience and after the contributions of König. . . . .

"To sum up, it evolved that the tumor was much more extensive than I had supposed. The carotid artery, the subclavian artery, the internal jugular vein, and the subclavian vein entered the tumor. I decided to ligate the common carotid and the subclavian in its first portion, a ligation which ranks with the ligation of the innominate artery.

"I accordingly resected half the clavicle, a piece of the first rib 2 inches long, a piece of the manubrium sterni 2 inches broad and 1½ inches high, and hereupon, after having cut through the sternomastoid, sternothyroid, and sternohyoid muscles, likewise the posterior layer of the fascia profunda diagonally, and the periosteum vertically in the whole exposed space, I had the subclavian vein, the jugular vein, the junction of these two, and the left innominate vein lying freely before me. Since the veins ran into the tumor, I ligated first the left innominate vein in order to guard against the aspiration of air. After double ligation of the left innominate vein the common carotid was doubly ligated directly behind the sternoclavicular articulation and cut through. The subclavian artery at this point lay unusually deep and was pushed still further back by the tumor.

"The pleura inflated greatly with each inspiration. At last I freed the subclavian artery from the surrounding tissues below inwards and behind and doubly ligated it, at the most 1.5 cm. from the arch of the aorta.

"The operation was performed with the greatest ease and comfort as soon as I had oriented myself as to the location of the subclavian; however, it is incomprehensible to me how one is able to complete the ligation with any surgical satisfaction and certainty without this extensive exposure. After the ligation of the innominate vein, of the common carotid, and of the subclavian (central), and after ligation of the subclavian vein, the internal jugular, the common carotid, and the subclavian (peripheral), the operation was easily completed. The whole procedure consumed 1½ hours. Unfortunately, the vagus nerve, which emerged from the tumor, had to be cut through; likewise the jugular trunk of the lymphatic system in the neighborhood of the transverse process of the third or fourth cervical vertebra was opened, so that a stream of lymph poured into the wound.

"In the thorax it was very easy to avoid wounding the thoracic duct, likewise the transparent pleura fluttering back and forth: altogether the operation was accomplished with the same ease and calm as at the dissecting table.

"The patient recovered somewhat after the operation and felt relatively well and had no dyspnoea; nevertheless he collapsed suddenly 18 hours thereafter, having said a short time before death that he felt quite well."

There is no pathological report.

W. S. Halsted. (V.) *Ligation of the first portion of the left subclavian artery and excision of a subclavioaxillary aneurism.* Johns Hopkins Hospital Bulletin, Baltimore, 1892, vol. iii, p. 93.

" Surg. No. 1589. Levin Waters (Plate XXVII), colored, aet. ' 52 ' (?) years, was admitted to The Johns Hopkins Hospital April 30, 1892. Patient is a vigorous man, gives a good family history and denies having had syphilis. Was perfectly well until eight months ago; he then noticed a small swelling about the size of a Madeira-nut under the left clavicle. He is sure that there was at this time a distinct pulsation in the tumor. He ' could feel it beat like my heart ' when he put his finger upon it. The tumor has grown rapidly since it was first observed. Until one month before the operation the patient worked regularly, did heavy lifting, etc., and had experienced little or no discomfort from the aneurysm. His only symptoms were a slight numbness in the left hand and forearm, and, subsequently, a shortness of breath and a hoarseness—both of which he attributed to a cold.

" Patient says that he has never had a pain which could be referred to the tumor.

" On admission the patient had an almost spherical, perfectly smooth tumor under the left clavicle. It was somewhat flattened on the side which pressed against the chest wall, and measured 42 cm. in circumference at its base. The middle third of the clavicle was overlapped and almost concealed by the tumor.

" Internally the tumor extended to within 5 cm. of the left sterno-clavicular articulation, and externally to within 4 cm. of the coracoid process. It was only after careful inspection that pulsation could be seen. To the touch the tumor was quite solid but elastic, and it was not easy to appreciate the feeble expansile pulsation. No pulse could be felt at the wrist nor anywhere below the aneurism. The left arm was neither swollen nor perceptibly cooler than the right.

" *Operation, May 10, 1892.*—The skin incisions: 1. Horizontal, about 33 cm. long, from the sternal notch to the acromioclavicular articulation, and thence down the arm to the lower border of the major pectoral muscle over the greatest convexity of the tumor. 2. Ascending, vertical, about 5 cm. long, from the inner end of the horizontal incision. 3. Descending, vertical, about 10 cm. long, from the middle of the horizontal incision. 4. Ascending, vertical, about 4 cm. long, from the horizontal incision at the acromioclavicular articulation.

" The flaps so outlined were reflected: The first, upwards and outwards; the second, downwards and inwards; the third, downwards and outwards. The inner third of the clavicle was then excised. Its middle third was somewhat eroded by the aneurism which slightly overlapped it.

" The wall of the aneurism was inflamed, soft, and so very thin where it pressed upon the bone that it would have been imprudent to attempt to dissect this part of the clavicle from the tumor.

" The next step in the operation was the deligation of the first portion of the left subclavian artery. This portion of the artery had been drawn down by the tumor, so as to occupy a horizontal position rather than a vertical one. It was entirely concealed by the subclavian vein, and lay below and behind the vein instead of above and behind it. I thought for a moment

that it might be necessary to excise a portion of the first rib in order to expose the artery. Two strong silk ligatures were applied to the artery as it emerged from the chest, and the vessel was divided between them. The deltoid muscle was cut through a little below the clavicle, and the clavicle sawed through at about 2.5 cm. from its outer end. The aneurism, the greater part of the clavicle, a piece of the deltoid muscle and about 6 cm. of the subclavioaxillary vein were then removed in one piece. The vein was intimately adherent to the aneurism. The axillary artery was ligated at the beginning of its second part. The operation as a whole was a tedious one and consumed 3½ hours. The wound was closed with interrupted buried skin sutures of fine black silk. The large dead space incompletely covered by the skin was bridged over with gutta-percha tissue.

"*May 23, 1892.*—At this, the second dressing, 13 days after the operation, it may be observed that the dead space is almost completely filled with a blood clot. This clot has not broken down and is quite throughout replaced by granulation tissue. The patient has not had a disturbing symptom since the operation.

"The left arm has never swelled and has at no time been cold. For a few days only there was a slight numbness of the tips of the fingers and particularly of the thumb. The case was altogether a most fortunate one for operation in that, thanks to the clot which occupied the sac, the collateral circulation had already been well established."

In a recent number (January, 1920, vol. vii, p. 390) of the *British Journal of Surgery* Mr. L. R. Braithwaite,[7] of Leeds, recounts interestingly his quite stirring experiences in excising an aneurism, about the size of a hen's egg, of the right subclavian artery. This is the fifth case of which I happen to know of excision of a subclavian aneurism, Moynihan's [33] (1897) being the second, Dunow's [14] the third, and Duval's [15] the fourth. With these the case of Schopf [52] might be perhaps enumerated, although Schopf's aneurism was essentially of the axillary artery, his proximal ligature being applied from below the clavicle.

In exposing his aneurism Braithwaite adopted the method of Moynihan, turning down in a flap of pectoral muscle a central piece of the clavicle.

The operation in all of the five cases was successful, but Moynihan's patient, who survived the operation of this brilliant surgeon 58 days, died on the 59th from rupture of another aneurism proximal to the one excised.

T. E. Schumpert. (VI.) *Ligature of the left subclavian in its first portion for aneurism of third* (*Recovery*). Medical Record, New York, 1898, vol. liv, p. 338.

"Ligature of the innominate has been undertaken in all 21 times, with one recovery.* The right subclavian has been ligated in its first part 15

* The innominate artery has been ligated once by my associate, Dr. Finney, and four times by myself at The Johns Hopkins Hospital. All of the patients recovered promptly. (W. S. H.)

times, with a similar result; the left subclavian has been ligated in its first part only twice, once by Dr. J. Kearny Rodgers, of New York, whose patient died of secondary haemorrhage on the thirteenth day. The second case is my own, which I am about to report.*

". . . . Wyeth considers the operation of ligation of the first part of the left subclavian as the most formidable in the domain of operative surgery. Sir Astley Cooper † failed in an attempt to secure the vessel, and is said to have wounded the thoracic duct. Jacobson, in his 'Surgery,' writes: 'It seems most doubtful whether the improvement in modern surgery will ever render this a successful operation; however, as it affords good practice on the dead subject, it will be given.' Erichsen considers the operation as bad in principle and most unfortunate in practice, and that it should be banished from surgical practice. Bryant says ligature of the subclavian in its first part on the left is scarcely practicable, and Mulley says the operation is quite out of the question. Treves believes that no artery could be less favorably placed for the application of a ligature, and in like unencouraging manner treat all authorities writing on this subject. Yet in the face of these words of warning emanating from the brightest stars of the surgical world, when confronted with a malady so universally fatal, we are prompted to summon courage and skill and attempt what has heretofore seemed an impossibility.

"A negro . . . . J. H., aged 56 years, was admitted to the Shreveport Charity Hospital with an aneurism, about the size of an orange, involving the third part of the left subclavian. The corresponding shoulder and arm were very oedematous and supported by the right hand. He complained of a constant great weight and aching of the parts; that he never had one moment of relief. He stated that about April 1st, while chopping a piece of timber overhead with a heavy axe, suddenly his arm gave way and the axe dropped by his side. After he had rubbed his arm for a moment its usefulness was restored and he proceeded with his work. Shortly after this a small pulsating tumor was noticed in the supraclavicular fossa, which obtained the

* "It is true, however, that Dr. Halsted recently successfully ligated this vessel for the extirpation of a tumor. It was not ligated in continuity and the operation was altogether a different procedure with a different aim in view."

† The aneurism in this case of Sir Astley Cooper was below the clavicle and forced this bone upwards. He attempted to tie the subclavian artery external to the scaleni muscles—not in its first portion.

The London Medical Review, 1809, ii, p. 300. "Medical and Surgical Intelligence, Art 2. In a case of subclavian aneurism which lately occurred in Guy's Hospital, Mr. A. Cooper attempted to tie the subclavian artery above the clavicle. The aneurism was very large, and the clavicle was thrust upward by the tumour, so as to make it impossible to pass a ligature under the artery without incurring the risk of including some of the nerves of the axillary plexus. The attempt was therefore abandoned. This artery has been successfully tied *below* the clavicle by Mr. Keate, but never yet as far as we know, *above* that bone."

"Case of subclavian aneurism, which occurred in Guy's Hospital, London; communicated to Dr. Miller, by Valentine Mott, M. D., Corresponding Member of the Medical Society of London, etc."

The Medical Repository, N. Y., 1810, third Hexade, vol. i, p. 331. (W. S. H.)

size of an orange a month later (March 7th), when I operated. . . . . My incision was begun on the sternum, two inches below its crest, and carried across the sternoclavicular articulation parallel to but one-half an inch external to the inner border of the sternomastoid muscle, the entire incision measuring seven and one-fourth inches. I then divided the sternal attachment of the sternocleidomastoid muscle, and penetrated the deep fascia by blunt dissecting with flat curved scissors. I was now brought in contact with the internal jugular vein and actually denuded the carotid artery of its sheath two inches in an attempt to go between it and the vein, but at last was compelled to abandon this route and proceed by the tracheal side to the inner edge of the scalenus anticus muscle, half an inch above the first rib. My finger placed at the bottom of the wound first recognized the dorsal vertebra, then the artery, which was dissected clean, and an aneurism needle, carrying No. 8 braided silk, passed beneath it from the inner side. The pulse in the left arm was now taken note of and found to be of the same character as when the operation was begun, but when the ligature was tightened it ceased entirely. I was careful to see that no twist was in my ligature, that the side and not the edge lay in contact with the vessel, and that it was drawn only sufficiently to control entirely its circulation. A second ligature in like manner was placed about one-sixteenth of an inch above. The broad base of my first incision rapidly formed itself into a cone with a very narrow apex, which made ligature of this deep-seated artery extremely difficult. During the operation I found it necessary to use a long-bladed smooth retractor in order that it might be applied deeply in the wound and press away the jugular vein and aneurismal tumor, which was almost in contact with the trachea.

"The divided segment of the sternomastoid muscle was brought together with catgut and the wound closed with catgut and dressed with iodoform collodion. Primary union subsequently followed under one dressing. It was not necessary to ligate a single bleeding point. My patient made an uneventful recovery, and is making himself generally useful about the hospital in this, the ninth week after operation. The oedema of his arm, shoulder and hand has entirely disappeared, normal function being about restored, but no radial pulse is yet perceptible in the left arm." *

F. Kammerer. (VII.) *Ligature of the first portion of the left subclavian artery for aneurism; death after four weeks.* Medical Record, New York, 1899, vol. lvi, p. 924.

"L. W., aged 47 years, was admitted to the German Hospital, in New York, on September 27, 1899. Twenty years ago he had contracted syphilis, but had had no secondary or tertiary lesions, according to his statement. In July of this year, he for the first time noticed a small swelling in the left supraclavicular region. He distinctly stated that he had received a blow at this point, some weeks previous. The growth gradually increased in size until he came to the hospital. For three weeks he had noticed a numbness in the third and fourth fingers of the left hand. When I first saw him, a

* Was the aneurism cured? (W. S. H.)

tumor about as large as a man's fist, was present in the region above stated. The tumor was in part covered by the sternal end of both the left sternomastoid muscle and the clavicle. It entirely filled the angle formed by them, and overlapped the clavicle to a slight extent. Immediately above the clavicle, it was in close relation and adherent to the skin covering it. The pulse at the radial artery was scarcely retarded on the left side. Expansile pulsation of the tumor was very marked. There was no dullness on percussion of the anterior upper part of the thorax.

"The case seemed a very urgent one indeed, more especially as the aneurism was already adherent to the skin above the clavicle and evidently preparing to rupture. I therefore concluded that palliative treatment would be of little value, and that the patient's only chance lay in ligature of the subclavian on the cardiac side, the distal ligature being unavailable owing to the many collateral branches of the sac. I was encouraged in this view by the belief that the aneurism did not extend for a great distance into the thorax, and, secondly, by a perusal of Wyeth's able article on 'Special Aneurisms,' in his 'Text-Book of Surgery,' where the author gives a more favorable prognosis of ligature of the left than of the right subclavian artery. He bases this opinion mainly on the unfortunate position of the innominate artery, which is in a direct line with the impact of the blood current forced out by the left ventricle.

"*Operation.*—October 18, 1899. Under chloroform a transverse incision passing over the ends of both clavicles and the manubrium of the sternum, fully six inches in length, was made. A vertical incision in the median line of the body, beginning at the cricoid cartilage and meeting the transverse incision on the sternum, was now added. The flaps thus outlined were dissected from the underlying parts. With the help of Gigli's saw, about one and a half inches of the right and two inches of the left clavicle, bordering on the sternum, were resected. The aneurism was in such close relation to the left clavicle that great care had to be taken at this stage of the operation. The upper end of the sternum was now removed for about a half an inch. The two innominate veins were thus exposed, whereupon it became apparent that access could not be had to the left subclavian artery, owing to adhesions of the left subclavian vein with the aneurism, as a result of which the space between the first left rib and the left innominate vein was entirely too small for any manipulations at such depth as is made necessary by the course of the subclavian artery after its origin from the aortic arch. I, therefore, resected two inches of the sternal end of the first rib, and removed the corresponding part of the manubrium. Even now, the arch formed by the superior vena cava and mainly by the left innominate vein, below which, of course, I had to search for the subclavian artery, proved a great hindrance, as I did not venture to dissect the innominate vein from the aneurismal sac. Two blunt curved retractors were inserted below the venous arch, and the latter was, with great care, pulled somewhat in an upward direction, out of harm's way. However, during the entire operation I was in continual fear of a lesion to these vessels, as at times strong traction had to be exerted upon them. I now separated the tissues to the left of the three arteries springing from the arch of the aorta, with my fingers, and as I was doing this I could very distinctly, in turn, recognize by the touch first the innomi-

nate, then the left carotid, and finally the left subclavian artery, the latter at about a distance of two and a half inches from the posterior surface of the sternum. When pressure was exerted upon the subclavian with the tip of my finger, forcing it toward the vertebral column, pulsation immediately ceased in the aneurism and in the left radial artery. Under such circumstances, it was impossible to expose the subclavian artery to view, and then to separate it from its sheath. To accomplish the latter, I had to rely upon the sense of touch, and separation of the artery from the surrounding tissues was done entirely by the aid of my left index finger and a pair of long curved scissors, which were not used as a cutting instrument. Contrary to my expectations, I succeeded in this very well, and I soon had the vessel sufficiently isolated to think of passing a ligature around it. This proved a very difficult task, however, and it was only after many and prolonged attempts that I succeeded in passing an aneurism needle and a thread. With the assistance of the latter, I also passed the ligature beneath the artery. It consisted of several pieces of chromicized catgut, wound together. I now tightened the first hitch of a surgical knot until I felt a resistance, and until pulsation in the aneurism and the arteries of the left upper extremity entirely ceased, my object being to stop the circulation, but not to injure the coats of the vessel. The knot was now completed. No drainage was established from the seat of the ligature, but the soft parts were allowed to come together, closing the deep wound cavity. The vertical incision was entirely closed by sutures, as were also the ends of the horizontal incision, thus covering what remained of the clavicles. The remainder of the wound was covered with loose gauze. The operation had lasted over three hours.

"The course of the case for the first three weeks was entirely uneventful. After the first few days, the patient's temperature and pulse became practically normal, and the wound cavity was soon lined with healthy granulations and filled up rapidly. On the day after operation there was no pulse in the left radial nor in the aneurism. The latter had decreased considerably in size. The left arm was not swollen, nor was its temperature appreciably lowered, and sensation and muscular power were intact. On the following day, October 20th, there was faint pulsation at the left radial, but none could be detected in the aneurism, and sensation in the arm was slightly retarded. . . . .

"*October 25th.*—The patient complained of shooting pains in the left arm. October 30th: There was slight oedema of the left hand. . . . . November 6th: On that day the patient complained of a feeling of weakness. Temperature, 101° F.; pulse, 120. On removing the dressings, it was seen that they were saturated with a considerable quantity of fresh blood. Several clots were found on the wound surfaces, which otherwise had the appearance of healthy granulations. On the left side, near the aneurismal sac, a blood clot lay, which was firmly attached to the surrounding tissues.

"From this time until November 15th, the dressings, which were changed at least once a day, were always filled with blood, although when they were removed no bleeding point could be found on the granulating surface. . . . .

"November 15th: The patient showed the effect of the continuous loss of blood during the last ten days. At 1 p. m. there was a sudden and very

severe haemorrhage, saturating the dressings and the bed linen. . . . . There was slight collapse, but he rallied well.

"November 16th.—At 4 a. m. another haemorrhage occurred. . . . . At 2.15 p. m., death from exhaustion took place, on the thirtieth day after operation.

"*Autopsy.*—At the autopsy, it was found that haemorrhages had been caused by rupture of the artery at the site of the ligature. The wound was in an aseptic condition. The loop of chromicized catgut had been to a great extent absorbed, especially at the point immediately opposite the knot, but a few strands were still present here, to hold the loop together. The latter had cut through the coats of the artery and almost completely severed the vessel; but it was still lying within the lumen. The knot, however, rested on the outside of the vessel. The distance from the aorta to the ligature was one inch. There was not the slightest trace of a clot on the proximal side of the ligature. The aneurismal sac was lined on its inner surface with a layer of fibrin, varying from one-half an inch to an inch in thickness.

"The left subclavian artery has to my knowledge been tied twice before in its portion as it emerges from the thorax, once by Kearney Rodgers in 1845 with a fatal result, and once by Halsted during extirpation of an aneurism as a preliminary step. His patient recovered. In my own case the situation of the aneurism made such a procedure impossible and necessitated the application of a ligature nearer the aortic arch. The unfortunate final result after an undisturbed course for several weeks was rather discouraging. I had used an absorbable ligature, and the wound surfaces had closed around the same without suppuration—two requisites for a favorable result after deligation of large arteries. Whether or not I avoided rupturing the inner coats of the artery while tightening the first hitch of the surgical knot, I cannot say—a very important point, according to the experiments of Ballance and Edmunds, Senn, and others. 'The living and uninjured wall is the only true safeguard against haemorrhage.' * to quote Ballance and Edmunds,[3] and this must be especially true of the first portion of the subclavian in man, as the walls of this artery are exceptionally thin in proportion to its size. The clot on either side of the ligature has really little to do with the tissue transformation that occurs within the uninjured vessel and about the aseptic ligature, leading to permanent occlusion of the artery. Some authors (Bruns) even believe that when the coats are not ruptured clotting does not occur. In my case there was no trace of a clot on the proximal side of the ligature, but I cannot accept this as a proof of my not having injured the coats during the application of the ligature. Senn's plan of applying two ligatures, at some distance from each other, thus leaving a bloodless space between them, was not applicable to my case. Nor did I feel that I could have applied a stayknot, as Ballance and Edmunds recommend, with any amount of exactness, owing to the depth of the wound. Still it seems to me now that an attempt should always be made, in ligating large arteries, to pass several ligatures. We will thus most

* I cannot endorse this statement of Ballance and Edmunds, Senn, and others, for, in my opinion, the force required to occlude the artery necessarily causes necrosis of its wall at the site of the ligature. (W. S. H.)

readily avoid injury to the coats of large vessels and succeed in arresting the circulation."

To Kammerer belongs the credit of having been the second to ligate the left subclavian artery within the thorax, Bardenheuer (1886) being the first. The operation, courageously and cautiously performed, was, for its time, a surgical feat of the first magnitude. The leak in the artery at the site of the ligature probably began not later than the seventh day after operation, when the patient first complained of shooting pains in the left arm, although there was no external indication of haemorrhage until on the eighteenth day the dressings were removed. This is the story of a ligature in an aseptic wound cutting its way through an artery. At the autopsy it was found that all but a few of the strands of the catgut had been absorbed; thus, the ligature had been reduced to a size dangerously small. The cause of the fatal result was probably either the fineness of the remaining strands of the ligature or an incomplete occlusion of the artery due to absorption of the catgut or to the slipping of the knot.

Dr. Kammerer felt that "the unfortunate result after an undisturbed course for several weeks was rather discouraging." It would indeed be discouraging were we not in a position to profit by the lesson which it and similar cases have taught. Let the surgeon who is about to ligate a large artery bear in mind the following facts:

1. Fine ligatures cut through the arterial wall more rapidly than coarse ones.

2. Partially occluding ligatures and crushing ligatures are dangerous.

3. Absorbable ligatures may disintegrate unevenly, and thus a coarse ligature be reduced to a fine one; or the knot may slip and thus convert a total into a partial occlusion.

4. Intimal surfaces brought in contact cannot unite because the wall of the artery becomes necrotic under the coarcting ligature.

5. The necrosed wall under ideal conditions becomes converted into fibrous tissue, into a solid cord by the in-growth of blood vessels from the ends.

6. Under certain conditions, for example when the lumen has not been totally occluded, or the wall of the artery has been too severely crushed, haemorrhage may be prevented by the formation of a fibrous tissue capsule enveloping the ligature and the arterial defect. Moderately coarse ligatures may, without causing leakage of blood, cut their way through an artery ligated in continuity. In the wake of such a slowly cutting ligature, a partially obturating diaphragm is likely to form. There may be several crescentic-like diaphragms, their free concave edges bounding the lumen which remains.

7. A coarser ligature should be used in tying an artery in continuity than for occluding the ends of a divided one.

8. It is probably safer, when feasible, to divide an artery, tying off the ends, than to ligate it in continuity.

9. Catgut ligatures should not be employed, lest some strands be absorbed or loosened before the others, and it is probably inadvisable to tie with a bundle of threads of any kind. It is decidedly risky to apply—as has been recommended and practised—a partially coarcting ligature central to the totally occluding one, for the arterial wall eventually giving way as it must under the former, it is only by the formation of an enveloping fibrous tissue capsule or by repair in the wake of the cutting thread that fatal haemorrhage is prevented. For the ligation in continuity of large arteries I have been using narrow tape.

10. The wound should be closed without drainage, and completely.

11. If infected, the wound should be promptly and freely opened and treated by the Carrel method with an antiseptic solution which will not endanger the devitalized wall of the artery under the ligature.

Dr. Jüngst (Saarbrücken). (VIII.) *Ein geheilter Fall von Unterbindung der Arteria subclavia sinistra am Aortenbogen.* Beiträge z. klin. Chirurgie, Tübingen, 1902, Bd. xxxiv, p. 307.

"Although the following case has already been published as a dissertation by my one-time assistant, Dr. Philipp,[45] yet I may be permitted to communicate it again as a statistical contribution, since it would appear that up to this time it is the first case of ligation of the subclavian artery at the arch of the aorta which has resulted in cure, and since it may be difficult to obtain access to Dr. Philipp's dissertation.

"The patient, female, aet. 35, was shot in the left side of the neck on the night of June 12-13, 1899, the shot entering in front, and passing outwards and upwards. The injury was followed by severe bleeding, which ceased of itself, and the next morning the patient was sent to the Bürgerhospital of Saarbrücken.

"We find a poorly nourished, moderately anaemic woman. The skin in the left supraclavicular region is sprinkled with a large number of black grains of gunpowder, is red, inflamed and swollen, and the skin of the whole left side of the neck, shoulder and upper thorax almost to the other side of the chest is purple. About 2 cm. from the sternal end of the left clavicle, close to its upper edge, there is a pea-sized entrance wound with ragged burnt edges from which only very little watery blood can be pressed out. There is no exit wound. The whole supraclavicular region is filled with a hard-soft swelling, in which there is neither pulsation nor bruit. The radial and ulnar pulses are unchanged and on both sides are equal in strength; there is no perceptible difference in the height of the pulse wave. There are sharp shooting pains in the left shoulder, radiating towards the arm. The left upper arm is quite a little swollen; there is complete motor paraly-

sis of the whole arm, passive movements are very painful. The sensation of the skin to touch, temperature and pain is much diminished—in places entirely absent. There are no pulmonary symptoms.

"The presence of a large haematoma in the left supraclavicular fossa, considered in its relation to the serious haemorrhage which followed the gunshot wound, made it probable that a large vessel had been injured, although at the outset the subclavian artery seemed not to be involved, for the pulse in the left arm was normal, and no abnormal sounds were to be heard at the site of the wound. The complete motor paralysis had to be regarded, in part at least, as due to compression of the plexus by the outpoured blood, for it was unbelievable that a single bullet could have injured all the roots of the plexus, which at this point lie so far apart. The treatment for the moment had to abide the issue, for haemorrhage had ceased and closure of the involved artery seemed probable. Under bandages of acetated white clay the signs of inflammation subsided and movement of the first three fingers and sensation in the radial area improved; only in the ulnar region did paralysis and anaesthesia persist. The general condition was good.

"Suddenly, in the night of June 20-21, after the woman had complained the whole previous day of not feeling well, a haemorrhage occurred which was slight and of short duration, and which was controlled by a compressive bandage and ice. But the next day the condition was quite changed; the swelling in the left supraclavicular region had become much larger and showed distinct pulsation, the radial and ulnar pulses were barely palpable, motility and sensation were becoming less; but still no bruit was heard and no thrill felt.

"There can be no doubt now that in spite of the absence of symptoms at the beginning we are confronted with a wound of the subclavian artery, since the haemorrhage from one of the smaller arteries of this region would not cause pulsation of this sort in the haematoma or an almost complete suppression of the peripheral arterial pulse. Taking into consideration the topographical situation, this wound of the artery must in all probability lie in the neighborhood of the cleft between the scaleni muscles, and therefore the ligation would be unusually difficult and fraught with danger. For this reason an attempt was first made to produce thrombosis of the haematoma with injections of thinned chloride of iron (Liquor Piazza)—without result, it is true, because the injections were very painful and had to be discontinued as they excited the already nervous and over-sensitive woman. Since, in spite of ice and compressive bandages, smaller secondary haemorrhages frequently occurred (June 30th, July 6th, 12th, 14th, 19th), and on July 19th the radial pulse, which up to this time had been weakly palpable, entirely disappeared, the resolution to ligate had to be made and carried out. But meanwhile the topographical conditions had been made much more difficult by the oft recurring haemorrhages: there was a haematoma almost the size of a man's fist, which could be followed deep into the soft parts of the neck and had thinned the skin almost to perforation.

"On July 24, 1899, under chloroform narcosis, an incision, 10 cm. long, was made outwards from the insertion of the sternomastoid along the upper border of the clavicle, and one of the same length upwards along the lateral

border of the muscle. The acute-angled skin flap was dissected up, whereupon the muscle, lying like a smooth band on the tumor, was cut through below. On the clavicle, corresponding to the entrance wound, was found a shallow groove and in it a small detached bit of lead, which had evidently glanced off from the shot. Now beneath the fascia lay a thick black coagulum; this was being carefully removed towards the depths of the neck, when suddenly a great thick stream of blood gushed out of the wound. Happily we succeeded, by digital compression towards the depths, in suppressing further haemorrhage, although it was not possible to reach the bleeding point; first because it lay too deep, and further because the approach was covered by the compressing hand. Both angle incisions were so lengthened over the summit that the horizontal portion reached to the right sternoclavicular articulation, the oblique one as far as the second left rib; and now the sternal third of the left clavicle and the whole manubrium sterni were resected. Although the cervical aperture to the thorax was now opened, we did not succeed in identifying with certainty the subclavian artery at the inner side of the scaleni, because orientation was made very difficult on account of the indurated mass which had formed around the large haematoma. Therefore, one had first of all to locate the left carotid; by tracing this downwards, we were enabled to reach the arch of the aorta and there to expose the subclavian artery and ligate it with a silk ligature about 1.5 to 2 cm. from its origin. Now, after removal of the compressing finger the bleeding ceased, and we were proceeding with the evacuation of the coagula from the large cavity, when suddenly again a rather severe haemorrhage occurred, which was again controlled at the same spot by digital compression. By careful evacuation of the peripheral part of the cavity the subclavian artery was now discovered and followed centrally as far as the finger compressing it on the first rib, and here was found a longitudinal slit 3 mm. long, with sharp edges, on the upper part of the artery precisely at the point where it emerges from between the scaleni muscles. As it appeared quite certain that this subsequent haemorrhage must have been a retrograde one from the left vertebral artery, the subclavian was once more ligated peripheral and central to its wound. Bleeding now finally ceased and the entire large wound cavity was stuffed with strips of iodoform gauze, which were also carried as far as the arch of the aorta, without, however, coming directly into contact with the point of ligature. The cavity was reduced in size by some stitches from the clavicle to the sternomastoid.

"The course for the first few days was rather stormy, and quite marked collapse made repeated infusions of salt and injections of ether necessary. July 26th the temperature rose to 39.1° and quite a large quantity of milky fluid came from the dressing, necessitating frequent renewals of the superficial bandages, and the removal on July 28th of part of the iodoform gauze, whereupon the temperature gradually sank. The constant moistening with the milky secretion produced a maceration of the neck and back, which required special attention in order to prevent decubitus and eczema. This flow gradually diminished and ceased entirely August 6th. While the flow of chyle continued there was very marked thirst, which gradually disappeared as the leakage diminished. At each change of dressing all the loosened iodoform gauze was cut away, the last piece being removed August 6th. During the final days the wound and the dressings had a decidedly fetid

odor, evidently due to the putrefaction of the remains of the chyle in the tampons, but the temperature was normal, and the wound was granulating satisfactorily.

"On the first day after the operation the weakness was so great that the patient could not speak aloud. As the condition improved the peculiar rough sound of her voice was striking and made one suspicious of one-sided paralysis of the vocal cord. It was later found by laryngoscopic examination that there was a complete paralysis of the left recurrent nerve; this was still present when the patient was discharged. . . . . The radial and ulnar pulses did not reappear. Motility in the upper arm was regained very soon, in the forearm and hand only gradually. The wound healed slowly *per secundam* and was closed by the middle of October.

"The patient remained in the hospital until her recovery, and the left arm was treated with massage and electricity until December 2, 1899, when she was discharged with the following findings: Wound healed with a broad scar, left side of the neck sunken in on account of the absence of the cord of the sternomastoid. At the place of resection of the bones of the clavicle and manubrium sterni there are firm periosteal bone formations. Left arm can be moved in the shoulder-joint, but cannot be raised. The left hand can be lifted to the mouth, but cannot make a fist; fingers only very slightly movable, actively or passively. In the ulnar region sensibility of all qualities extinct; no striking atrophic changes. Complete left-sided paralysis of the recurrent nerve, voice loud and rough.

"In the foregoing case the cure was effected by ligation of the subclavian artery in its first portion. At the time of the publication of the dissertation, Dr. Philipp could not discover a case which had been cured by this ligation; all of the 18 * cases collected by him died very soon after the operation, which, as far as could be ascertained, had been undertaken only three times on the left side. I have searched the literature since that time and have not been able to find another cured case. My case may first of all prove that, under favorable conditions, a cure following this ligation is possible, and that the prognosis is not so absolutely bad that in a similar case one should not at least undertake the operation. Further, my case confirms what has been emphasized by all observers, the difficulty of diagnosis, which in this case was greatly increased because there was no real division of the artery, but only a lateral wound, which caused the symptoms of a severe wound to make their appearance gradually.

"The technical difficulties are naturally much greater on the left side than on the right and necessitate free exposure of the field of operation by the resection of a portion of the clavicle and of the manubrium sterni, whereby alone it is possible to orient oneself and to secure freedom of action. The wounding of the thoracic duct and of the recurrent nerve (or the vagus trunk?), which occurred in my case, are technical faults, which are certainly to be avoided and may be excused by the haste with which I was obliged to operate since the compressing finger of the assistant was becoming tired and had to be supported by the finger of still another

* Philipp's collection includes the ligations of the first portion of the right as well as of the left subclavian. (W. S. H.)

assistant. That the wounding of the thoracic duct does not always have serious consequences is also proved."

The first step in the operation of Dr. Jüngst should, in my opinion, have been the exposure and provisional occlusion of the thoracic portion of the subclavian. Had this been done the patient would have been spared the major part of the loss of blood. The evidence is insufficient to sustain the contention that the ultimate haemorrhage was altogether a retrograde one from the *vertebral* artery. I shudder to fancy what the result might have been in our second case (No. XXI) had I proceeded after the manner of Jüngst. To stuff the wound with gauze was also an error; the wound should, I think, have been closed without drainage, absolute haemostasis having, of course, been attained.

Charles Stonham. (IX.) "Westminster Hospital. *A case of aneurism of the second and third parts of the left subclavian artery; ligature of the first part; recurrent pulsation; simultaneous ligature of the inferior thyroid, vertebral, and third part of the axillary arteries; recovery.*" Lancet, London, 1902, vol. ii, p. 291.

"A man, aged 43 years, was admitted into Westminster Hospital on April 13, 1899, in consequence of a swelling 'in the root of the neck on the left side.' The patient had contracted syphilis 14 years previously and 10 months before admission he had a gumma on the left calf, one on the inner side of the left thigh, and a third on the left forearm. In November, 1895, he was admitted into St. Peter's Hospital, Bristol, in consequence of 'bronchitis and considerable haemoptysis'; he was an in-patient 10 months, when he was discharged as suffering from phthisis and being incurable. He was then admitted into the St. George's Infirmary, Fulham-road, and improved considerably. On his discharge he resumed his work as a carpenter and worked regularly until he came to the hospital, although he was 'troubled with his chest and a cough.' He had also suffered from piles and right-sided sciatica. As regards his present illness, five months before admission the patient experienced an aching pain in the upper part of the left chest and noticed a swelling of about the size of a walnut at the root of the neck above the left clavicle. This swelling was at first very tender, but the pain soon passed off and the patient put pressure on the swelling for two or three days, after which, according to him, it disappeared, but suddenly reappeared two or three days later. This swelling gradually increased in size, but although at first he occasionally suffered acute stabbing pain in the left chest and down the left arm this did not trouble him latterly and he continued his work until April 12, 1899, the day before his admission.

"On April 17th the patient was thin and had a worn expression. The chest was badly formed and its mobility was markedly deficient. The percussion note was somewhat impaired at the apex on both sides; there were no moist sounds or other abnormality; there was no expectoration. The heart was normal. The arteries were not rigid or particularly tortuous.

. . . . The ends of the fingers were clubbed, especially on the left hand. There was a swelling in the left supraclavicular region of about the size of a duck's egg rising well above the clavicle and situated over the third and part of the second part of the subclavian artery, extending forwards beneath the clavicular head of the sternomastoid to near the middle of the sternal head. The swelling occupied the whole of the supraclavicular fossa, but there was no dullness below the clavicle indicative of its extension in that direction, although it is true that there was deficient resonance at the apex of both lungs; this deficiency was equal on both sides. The swelling was expansile and there was a very distinct systolic bruit and thrill. The diagnosis was aneurysm affecting the convexity of the second and third parts of the left subclavian artery. . . . . After carefully considering this case in all its bearings and being convinced that rupture of the sac would occur in a short time, Mr. Stonham determined to attempt cure by proximal ligature in spite of the general opinion that such an operation should not be undertaken.

"*Operation, April 26, 1899.*—An operation was performed on April 26th. The patient was placed under chloroform and Mr. Stonham proceeded to tie the vessel in the thorax, being most ably assisted by Mr. E. P. Paton. The shoulders being somewhat raised by pillows, the head thrown slightly backwards, and the face turned to the opposite side, a vertical incision about six inches long was made parallel to, and just outside, the sternal head of the sternomastoid, the centre of the incision being placed over the sterno-clavicular articulation. The upper part of this incision exposed the muscular fibres while the lower half was made right down to the sternum. A second incision was then made along the inner half of the clavicle, the knife being made to cut down to the bone. The clavicular head of the sternomastoid was separated from its attachment, the clavicle being closely 'hugged' all the time; this part of the muscle with the upper triangular flap of skin was very carefully turned upwards and outwards. A small portion of the pectoralis major was now separated from the sternum and clavicle and was turned with the second triangular portion of skin downwards and outwards. The parts were very vascular but no vessel of any importance was encountered; all bleeding points were at once clamped and tied, the most troublesome one being a small perforating branch in the first intercostal space. The clavicle was now very carefully sawn about one inch, or rather more, from its sternal end, the division being completed with bone forceps; the sternal portion of the bone was isolated by means of a raspatory and by the knife, both instruments being kept as close as possible to the bone so that in point of fact the resection was practically subperiosteal. During the division of the bone the deeper parts were protected by a retractor. The floor of the wound was now seen to consist of a portion of the clavicular periosteum, a layer of the deep cervical fascia and muscular tissue. By means of two pairs of dissecting forceps the outer edge of the muscular layer was clearly defined, the muscles being the sternohyoid and the sternothyroid; these were drawn inwards. Further blunt dissection revealed the carotid artery running vertically upwards along the inner border of the wound which was now becoming very deep. On the outer side and below was the dome of the pleura covered by the junction of the subclavian and internal jugular veins and a short piece of the left innominate. These veins were

carefully drawn downwards and outwards, when deeply behind them about two thirds of an inch of the subclavian artery were revealed, surrounded by a little loose fat. The thoracic duct was not seen nor were any nerves or veins other than those mentioned. Little difficulty was experienced in passing an ordinary aneurysm needle armed with salicylic floss silk round the vessel from within outwards; the finger was then placed upon the vessel (which was apparently quite healthy and highly elastic) and the loop of the ligature drawn tight beneath it, the radial pulse and all pulsation in the aneurysmal sac were arrested, and the ligature was then tied with a surgeon's knot, the ends being cut quite short. The ligature was only tied with sufficient force to occlude the artery, not to rupture the inner coats; it was situated behind the sternoclavicular joint about half an inch from the aneurysmal sac. The deep wound was carefully dried and the displaced structures were allowed to resume their normal position, the sternohyoid and sternothyroid muscles completely hiding the artery from view. The skin wound was closed with silk-worm gut and horsehair interrupted sutures, a short gauze drain being placed in the middle of the incision as deep as the sternohyoid and thyroid muscles. The wound was dressed with double cyanide gauze and salicylic wool, the left arm, covered in Gamgee tissue, was bandaged to the side, and one-third of a grain of morphia was administered hypodermically. . . . .

"On April 27th . . . . he had slept for six hours and had been comfortable. The pulse was 84, regular, and of rather low tension. The temperature was normal. One of the fingers when examined was quite warm and the circulation was good. There was no pain. The pulse was 76. The circulation in the left hand was good and the radial pulse distinct. He complained a good deal of thirst. . . . . On May 2d the wound was dressed and the gauze drain was removed. Slight pulsation, not expansile, was felt in the sac, which was much smaller and harder. On the 9th the stitches were removed; the wound was soundly healed; it was now covered with a collodion dressing. The sac was smaller, denser, and more localised; slight pulsation could be felt in it, but could not be seen. The radial pulse was more distinct. From May 9th to June 2d the patient was kept quiet in bed. . . . . On the latter date the pulsation in the sac was distinctly excentric and the sac had somewhat increased in size in the outward direction. Until a week before June 21st this increased size of the sac slightly diminished, but now the pulsation was more evident, especially at the upper and outer part. The patient also complained of pain in the shoulder and down the upper arm. *The radial pulse was very good but delayed in time.** On the 22d equable and continuous pressure was applied to the sac by means of marine sponges and bandages. On the 24th there was no result from the pressure and it was consequently discontinued; indeed, the sac was clearly increasing outwards and upwards and the pulsation was becoming more evident. Dr. Allchin kindly saw the case with Mr. Stonham and it was decided that something further must be done. On the 27th the left hand was slightly swollen and congested and the patient complained that he could not move the fingers properly.

* Italics mine. (W. S. H.)

"On June 28th the vertebral, inferior thyroid, and the third part of the axillary artery were ligatured. A vertical incision was made just external to that employed for the previous operation and was carried further upwards along the outer border of the sternal head of the sternomastoid. A second incision was made from the lower end of this outwards along the line of the clavicle and this triangular flap of skin was then turned upwards and outwards; the remains of the clavicular head of the sternomastoid were drawn outwards and the internal jugular vein exposed. Blunt dissection external to the vein exposed the anterior scalene muscle and phrenic nerve. The jugular vein was drawn inwards and the muscle outwards. The transverse process of the sixth cervical vertebra was exposed. A vessel of no great size was now defined in the position of the vertebral artery and was ligatured with silk; the ligature unfortunately broke, dividing the vessel, which was secured with difficulty and tied at both ends. No other vessel could be found in this situation, though the foramen through the transverse process could be clearly defined. A second vessel—the inferior thyroid artery—was also tied. A piece of gauze was carried to the bottom of the wound as a drain and the incision was sutured with horsehair. Ligature of these vessels materially diminished but did not arrest the pulsation in the sac and it was therefore determined to apply a distal ligature to the third part of the axillary artery, and this was accordingly done just above the subscapular branch and was followed by complete arrest of the pulsation.

"On June 29th the patient was comfortable. . . . . The circulation in the fingers was good. The wound in the neck had oozed a little and the dressing was stained; this had been packed. On the 30th the wound was dressed and a smaller plug of gauze was put in the cervical wound. The wounds were healthy. On July 3d the patient was progressing satisfactorily and was kept on fluid diet. The dressings had not been touched. The circulation in the arm was good but no pulse was present either at the wrist or the elbow. . . . . On the 5th there had been uninterrupted progress. The wound was dressed and the sutures and gauze plug were removed. No pulse was to be felt. The aneurysm was decidedly smaller, harder and denser; there was no trace of pulsation in the sac. On the 11th the wounds were soundly healed. The aneurysm was still smaller and harder; over it slight pulsation could be felt along a transverse line (? the transverse cervical artery). The radial pulse was just perceptible. The further progress of the case was uninterrupted. The sac gradually diminished in size and the pulse became stronger in the radial. The patient complained for a few days of stiffness in the fingers. . . . .

Remarks by Mr. Stonham: "In November [year not stated] I saw the patient and could find absolutely no trace of the sac. . . . . The movements of the arm were necessarily weak. . . . . I have seen this man as lately as March, 1902, and he continues quite well. He is doing light work as a carpenter."

In Mr. Stonham's description of the primary operation no mention is made of the branches given off from the first portion of the artery; I presume, therefore, that he saw none and consequently did not know the position of his ligature in its relation to any one of them. Since, however, he

ligated the vertebral and inferior thyroid arteries at the second operation we may infer that he believed his ligation to have been made proximal to these branches.

Stonham's is the only aneurism of the spontaneous variety on our list not cured by the simple ligation of the subclavian artery. Since the artery coursed high in the neck and the aneurism was apparently at its highest point, and as, furthermore, the ligation of the vertebral and inferior thyroid arteries at the second operation had less effect on the aneurism than the ligation of the third part of the axillary, and as the radial pulse reappeared 24 hours after the first operation and 13 days after the second, I wonder if this may not have been a case of aneurism due primarily to a cervical rib—secondarily perhaps to the syphilis. It would seem that there must have been a well established anastomotic circulation before the first operation.

Surgeons have rarely noted the location of the ligature in its relation to the origin of the branches of the first division of the subclavian artery. Only from the cases in which this relationship is known could we find justification for inference as to the effect which secondary ligation of the branches in question might exert upon the aneurism. There can be little doubt, I think, that we should make for ourselves the rule always to ligate as close to the aneurism as possible, whether on its afferent or efferent side. I have never failed to cure the aneurism when both the afferent and efferent arteries have been ligated in accord with this precept. In one instance of this kind, however, the pulsation, which had ceased for a moment after the ligation of the artery on both sides of the aneurism, returned before the toilet of the wound was completed, but we noted that the sac became larger and tenser—a sign which I have learned to regard as favorable. At the first dressing of this case of mine,* which was not made until the 9th day after operation, the tumor no longer pulsated nor did it ever pulsate again. I have read of at least two similar observations, but unfortunately neglected to make a memorandum of either.

I do not understand why Mr. Stonham should have ligated the axillary artery at so low a point. A ligation as near the aneurism as possible would have been more likely to cure it and have less imperilled the circulation of the arm.

Pierre Delbet. (X.) *Anévrisme de la sous-clavière gauche.* Bull. et mém. Soc. de Chir., Paris, 1910, t. xxxvi, p. 1114. (Séance du 16 novembre, 1910.)

"I have the honor to present to you a patient upon whom I have operated for a traumatic aneurism of the left subclavian. I operated with the assis-

* Johns Hopkins Hospital, Surg. No. 18357.

tance of our colleague Pierre Duval, whose counsels have been extremely valuable.

"I first exposed the sac, because it was not absolutely certain that the aneurism had its origin in the subclavian: it might have developed at the expense of one of its branches.

"Then, I resected the internal third of the clavicle and a part of the manubrium in order to proceed with the search for the subclavian at its origin from the aorta. This was very deep. I passed a ligature beneath the artery and, pulling on this ligature so as to bend the artery and stop the circulation in it, I opened the sac. Formidable haemorrhage. Having tamponed and made compression, I proceeded with the search for the peripheral end of the subclavian, and I passed a thread underneath it as had been done for the central end. The two ligatures being tied, I removed the tampon. Haemostasis was not perfect, but the haemorrhage was not menacing.

"We could see the orifice through which the blood came and we closed it with two forceps. In spite of its deep location, it would perhaps have been possible to suture it, but I judged that this would not have been of any advantage. I ligated with a single ligature passed around the two forceps.

"As the patient had terrible neuralgic pains, *je réséquai les deux dernières paires cervicales,** which were imbedded in the fibrous tissue forming the sac. The pains completely disappeared.

"But the patient had irregular phenomena of paralysis, which made one think that the first 'fronto-dorsal' was wounded. I did not think it necessary to search for this root, the operation being already traumatic enough.

"The paralytic phenomena persist, and I do not know whether they will ameliorate, because it is impossible for me to determine whether the root has been divided by the stroke of the knife and secondarily compressed.

"The radial pulse, which was not perceptible before the operation, has not yet become so, but at no time has the nutrition of the member given the least anxiety.

"I shall not discourse further on this case, because I have to make a report on an analogous one of Dr. Pierre Duval." †

This would seem to have been a case for extirpation of the sac rather than for tamponage.

Ed. Schwartz. (XI.) *Enorme anévrisme diffus du cou et de la région sous-claviculaire. Paralysie du membre supérieur gauche. Compression du*

* Presumably *dissected free* is meant. It is interesting to note that the freeing of the nerves entirely relieved the pains. (W. S. H.)

† The case of Duval is probably the one announced by title at the séance of April 20, 1910, p. 420: "*Anévrisme de l' artère sous-clavière droite. Extirpation du sac après résection temporaire de la clavicule. Ligature latérale de la veine sous-clavière Guérison.* Présentation de la pièce anatomique et du malade, par M. Pierre Duval, chirurgien des hôpitaux.

"Le travail de M. Duval est renvoyé à une commission, dont M. Delbet est nommé rapporteur."

récurrent gauche. Bull. et mém. Soc. de Chir., Paris, 1910, t. xxxvi, pp. 874 and 1138.

Séance du 20 juillet 1910. M. Ed. Schwartz: "I have the honor to present to you this wounded man, for whose treatment I ask your advice. . . . .

"M. X., aet. 33, was thrown from his bicycle against the shaft of a cart which struck him in the left supraclavicular region. The accident occurred June 6, 1910, about 6 weeks ago. The patient did not lose consciousness, but got up, and noticed at the point where he had been struck the formation of a swelling which increased as he watched it, while the skin became tense and purple. He consulted a physician who ordered leeches.

"He returned to his home in the evening and felt greatly oppressed. The leeches were applied and gave relief.

"At the end of five or six days the tumor appeared to have diminished, the ecchymosis disappeared, the voice, which had been a little hoarse, regained its normal timbre; the patient remained in bed on a strict diet.

"Then there occurred attacks of pain in the left arm, especially at night. These attacks lasted about half an hour and were accompanied by contraction of the muscles of the arm. Pyramidon was ordered for him, and on June 13, 1910, the actual cautery was applied.

"From June 14th the tumor again began to increase in size and hardness during three or four days, and at the same time there appeared difficulty in breathing, roughness of the voice, and a complete flaccid paralysis of the left arm. The attacks of pain persisted. June 24, 1910, the patient entered the Hospital of Langres, where iodide of sodium was administered and electric treatment of the paralyzed muscles periodically given. As his condition remained stationary he was sent to the Hôpital Cochin, July 18, 1910.

Examination.—"One finds an enormous, tense, fluctuant tumor occupying the whole left carotid and supraclavicular regions, reaching from the jaw to the clavicle, and pressing the larynx and trachea to the right.

"One perceives neither pulsation, bruit, nor expansion of the tumor. The skin is movable over it.

"The left temporal pulse is hardly perceptible; the left radial pulse is feebler than the right but not appreciably retarded.

"The left arm is completely paralyzed; there is atrophy of the muscles, especially of the great pectoral; the patient can raise the shoulder by means of the clavicular fasciculus of the trapezius; sensation is preserved.

"There is raucity of the voice, which is a little muffled; there is dysphagia when solid food, especially bread, is taken; there are signs of compression of the left great sympathetic, manifest in the narrowing of the left palpebral cleft, in myosis and enophthalmus.

"Aspiration with a Pravaz syringe drew out a little black sanguineous liquid.

"In our opinion, we can only be confronted in this instance with the rupture of a large vessel of the neck. In spite of the absence of pulsation, we believe that there is a rupture of an artery like the carotid or subclavian; there have been two affluxes of blood, the first at the time of the accident, the second 6 days later when the severe symptoms of paralysis appeared.

"What treatment would you advise? Were it not for the paralysis and the atrocious suffering I would await developments in the hope of seeing the tumor diminish in size. Do these symptoms demand intervention, opening the sac, searching for and tying off the torn ends of the vessel?

"M. Lucas-Championniere: Is there definite amelioration, or is there aggravation?

"M. Schwartz: After a period of augmentation we observe undoubtedly a slight abatement.

"Several speakers took part in the discussion, some advising intervention, others abstention. It was demonstrated that the tumor was pulsating."

Séance du 23 novembre 1910. "*Anévrisme diffus de la sous-clavière gauche.* Communication par M. Schwartz." Bull. et mém. Soc. de Chir., Paris, 1910, t. xxxvi, p. 1138.

"I presented to you on the 20th of last July a patient with an enormous aneurismal tumor of the neck following a wound in the left supraclavicular triangle, and asked what course you would counsel me to take in such case.

"As the tumor was increasing and the patient was suffering continuously, my colleague Nélaton, who had the goodness to give me his valuable and illuminating advice, was with me inclined towards an intervention—to search for the two ends of the wounded artery, having first made as far as possible preventive occlusion of the wounded vessel, which, as will be remembered, might be the common carotid, but more likely the left subclavian or one of its large branches.

"After experiments on the cadaver, for which we are indebted to the kindness of our colleague Professor Hartmann, we thought of proceeding in the following manner: make a resection of the internal extremity of the clavicle and of the left half of the manubrium, search for the common carotid at its origin from the aorta, apply a temporary ligature to this artery, search for the very deeply situated subclavian, and against the vertebral column make digital compression of this vessel at its origin. Of course, the ligature was not to be permanently tied until, after splitting the aneurismal sac, the arterial wound had been located.

"In the meantime, I had the patient injected subcutaneously with 10 to 15 cubes of sérum gelatiné, one each day. Under the influence of this it appeared to us that the tumor diminished; at all events, the pains became much less intense and the general condition improved.

"My colleague Nélaton and I met to decide and to perform the projected operation. The tumor began to grow anew, and it seemed to us impossible to proceed with the claviculo-sternal resection without entering the aneurismal field and being immediately inundated with blood. In view of this conclusion we believed that we should refrain from operation, and continue to make the injections of sérum gelatiné and the application of bladders of ice. Meanwhile my wards were closed for repairs and the wounded man passed into the service of my colleague Quénu, under the care of our colleague Pierre Duval, who believed that he ought to operate and sent me the following note:

'*Operation.*—August 8, 1910. Doubtful as to whether the aneurism had its origin in the common carotid or the subclavian it appeared to me prudent to make a

search for these two vessels at their origin from the aorta, to place on each of them a temporary ligature, then, to split freely the aneurism and to find my way to the wounded artery as circumstances might permit.

'Incision parallel to the clavicle curving over the manubrium; resection of the clavicle (inner half), of the left half of the manubrium, and of the first costal cartilage.

'The pleura and pleural dome were pressed aside. The arch of the aorta was exposed. A ligature was placed about the left common carotid and also on the subclavian. Free vertical incision of the aneurism.

'At the moment the jet of blood spurted my assistant pulled quickly on the precautionary ligatures. After evacuation of the clots, I easily found the subclavian, cut across at the internal border of the first rib. Ligature of the two ends. Suture and drainage. The patient's pulse after operation was 84. The operation had lasted 50 minutes. At 3 o'clock in the afternoon, sudden death.

'I am persuaded that he died from an embolus. The ligature, placed as a precaution which I now recognize as useless and dangerous, on the common carotid, had been sharply drawn, must have wounded the internal coats of the artery, from which there was a clot and mortal embolus.'

"I cannot, in spite of the unsuccessful outcome, help felicitating our colleague Pierre Duval on the course which he adopted. I allowed myself to be halted through fear that I should not be able to control the haemorrhage; the operation which he performed has shown that that fear was unfounded. He added to the operation planned by Nélaton and me resection of the cartilage of the first rib, which gives still better access and permitted the application of a ligature to the subclavian. . . . ."

Whether the precautionary loop about the subclavian within the thorax was tied is not stated. In any event, the proximal ligation must have been of the first portion.

I am unable to share with M. Duval his confident belief that an embolus from the carotid artery was the cause of the patient's death. Have we any proof that embolism of a cerebral artery has ever caused sudden death, or have we evidence that, infection being excluded, emboli may become dislodged or a thrombosis form as the result and at the site of a temporary ligature? Many times have I occluded temporarily large arteries in the human subject and never have I had occasion to regret it. The aorta of dogs, which on the average is not larger than the carotid of man, we have repeatedly ligated as a temporary measure and have never observed thrombosis at the line made by the crushing ligature. In any event, the temporary occlusion of arteries should, when possible, be made in a manner not likely to rupture their coats.

I commonly employ a narrow tape in making temporary occlusion. Close to the artery the two arms of the tape are twisted and the twist maintained by clamping it with an artery forceps. Dr. Mack Rogers of Birmingham, Alabama, discussing the paper of Dr. Sherrill, advocates the following method:

"In connection with this subject of aneurysm, I desire to call attention to a method of controlling haemorrhage that has been of great utility in these cases. It is the use of an ordinary white tape that is used for binding

purposes. It should be about 12 inches long and half an inch wide. An aperture is provided about one inch from the centre, through which the other end of the tape is carried after it has been passed around the vessel; then by pulling on the two ends of the tape, pressure is exerted over a broad area of the vessel, controlling the haemorrhage perfectly, yet it does not injure the vessel. By the use of this tape an assistant is in absolute control of the situation. He can increase or diminish the pressure on the vessel at will, while the operator is dealing with the aneurysmal sac, and this will greatly assist the operator in locating the vessels that enter the sac.

"This method of controlling haemorrhage is, of course, not an entirely new one, but I wish to call the attention of this Association particularly to its application in these desperate cases of aneurysm."

Capt. C. G. Browne. (XII.) *A case of diffuse traumatic aneurism and ligature of the first part of the subclavian.* British Medical Journal, London, 1911, vol. ii, p. 1534. (Reports on medical and surgical practice in the hospitals and asylums of the British Empire. Station Hospital, Barrackpore, Bengal.)

"Ligature of the first part of the left subclavian artery is an operation attended by many difficulties and dangers. I have only been able to find two successful cases recorded of ligature on the right side and none on the left. My references are, however, limited. Erichsen condemns the operation as 'bad in principle,' and 'most unfortunate in practice,' and considers that it should be 'banished from surgical practice.' Hence a few notes on a recent successful case may be of interest.

"Private C. was brought to the hospital on the evening of August 25, 1911. He was faint and his clothes were blood-stained. He had been on guard, had fainted, and fallen forwards on his bayonet, the point of which had entered through the left anterior axillary fold for an uncertain distance. There was no bleeding from the wound, but there was evidence of a collection of blood in the subclavicular region and inner part of the axilla. He complained of an aching distended feeling in the arm. The wound was dressed and pressure applied. The temperature in the evening was 100.6°.

"The patient had a restless night, but no external haemorrhage; there was marked pulsation and a bruit over the subclavian swelling, which had not increased in size. The left radial pulse, which was at first feeble, was now equal to the right. The venous return from the arm was apparently slightly obstructed. The temperature was 99.8° in the morning and 100.4° in the evening. He had another restless night, and on the morning of August 27th he complained of severe pain down the arm, which was slightly swollen; the pulsation, bruit, and size of the swelling were unaltered. The temperature was 99.6° in the morning and 100.4° in the evening. He had a very restless night, being almost delirious with pain, and had attempted to tear off his bandage. Ou August 28th the arm was more swollen, and the obstruction to the venous return was more obvious. I saw him for the first time on this day in consultation with Lieutenant-Colonel F. J. Morgan, R. A. M. C., and decided to operate at once. The temperature was 99.4°.

"*Operation, August 28, 1911.*—The usual incision for ligature of the third part of the subclavian was made, the omo-hyoid was pulled up, and

the outer border of the scalenus anticus exposed. Owing to the clavicle being very much pushed upwards and forwards, the wound was of considerable depth. No trace of either subclavian artery or vein could be found external to the scalenus anticus muscle. The wound was extended inwards and the sternomastoid partially divided; the depth of the wound increased, and presently a large artery, partially overlapped on its inner side by a vein, was exposed, descending vertically along the inner border of the scalenus anticus. The wound was now very deep, and the greatest care had to be exercised. Unfortunately at this point a small vein was torn close to its junction with the large vein and the wound was flooded with blood. A ligature was placed on this after much trouble and waste of valuable time. The artery was now compressed by the finger and the radial pulse was at once obliterated; pulsation below the clavicle also ceased. The vessel was taken to be the first part of the subclavian and was ligatured. The passing of the ligature took some time, as I had to proceed with the utmost caution, and the depth of the wound and condition of the patient did not warrant me in tracing the artery any further. The wound was sewn up, leaving a gauze drain. The axilla was then opened, clot and serum evacuated, and a large drainage tube inserted. The temperature in the evening was 102.8°.

"On August 29th the part was dressed, a light plug inserted in the upper wound, and a tube left in the lower. The temperature was 99.4°. He stated that he was absolutely free from pain in the arm but there was a slight tingling of the fingers. There was no pulsation below the clavicle and no radial pulse. The arm was kept swathed in cotton wool.

"On September 4th he was doing very well; there was a little serous exudation from the upper wound.

"On September 18th both wounds were completely healed; there was some stiffness about the muscles of the shoulder, which was being massaged. No pulse could be felt in the radial artery.

"On September 27th he was discharged from hospital, complaining of some numbness of the first and second fingers.

"On October 11th he was marked 'light duty' for one week (before resuming his full military duty on October 18th). No pulsation was felt in the radial artery.

"The chief point of interest about the case was the abnormal course of the artery. When first exposed I thought it must be the common carotid from its vertical course. The result of the ligature, however, leaves no doubt that it was the subclavian. The vessel must have either (1) made a very high arch in the neck on the inner side of the scalenus anticus, or (2) taken origin from the common carotid in the neck instead of from the arch of the aorta, though this is an abnormality I have never read of. The almost immediate relief of the pain, presumably due to nerve pressure, was a gratifying feature. I am indebted to Lieutenant-Colonel F. J. Morgan, R. A. M. C., for his invaluable assistance during the operation and permission to publish this case."

As there was no pulsation in the axillary haematoma and no haemorrhage after evacuation of the clots it is improbable that the axillary artery had been pierced by the bayonet. Possibly only a vein was injured. I should

not be inclined in a case like this to make a permanent ligation of the subclavian. Compression of the artery above the clavicle would have been especially easy as the artery coursed high in the neck.

The "high arch in the neck" of the subclavian artery must have simplified the operation greatly. The former of Captain Browne's two conjectures in regard to the "abnormal course of the artery" is quite surely the correct one. My studies, clinical and experimental, on the dilatation of arteries distal to the point of coarctation have led me to observe with greater interest and care the course of the subclavian artery in patients with cervical ribs and also in those without them, and I have been surprised at the frequency with which the subclavian occupies an abnormally high position in the otherwise apparently normal neck, sometimes quite as high as in people with cervical ribs.

My colleague, Professor Howland, recently called my attention to a child's neck, the configuration and great length of which convinced him that the boy had a cervical rib or ribs. The subclavian artery coursed so high above the clavicle that from this sign alone I was quite sure that Dr. Howland's interpretation was correct. The skiagraph showed abnormally large transverse processes of the seventh cervical vertebrae, but no trace of cervical ribs. We shall follow skiagraphically the development of the neck of this boy in the expectation that the unossified primordium (Anlage) for a cervical rib may be present.

Is it not probable that the occurrence of very high subclavian arteries in people without cervical ribs may be traceable to an Anlage for the undeveloped ribs? We have several times found in these cases stumps of bone articulating with the transverse processes of the seventh cervical vertebrae, and in one such case there were definite symptoms of pressure on the roots of the brachial plexus, symptoms which were relieved by the removal of the abnormal stump of bone, although at the operation in this case we found nothing to explain the relief afforded by it.

I hope that some younger men who read the above paragraphs may be interested to note skiagraphically for a period of years the cervical development of children with abnormally long necks and high subclavian arteries.

JAMES M. NEFF. (XIII.) *Ligation of the first portion of the left subclavian artery. With report of a recent successful case.* Annals of Surgery, Phila., 1911, vol. liv, p. 503.

"Mr. H. W., age 23 years, single. In December, 1909, patient first noticed an enlargement of the glands in the left side of the neck.

"Patient entered the Deaconess Hospital, Spokane, on February 11, 1910. In left side of neck there was a chain of enlarged lymphatic glands extend-

ing from the mastoid process to the clavicle. The centre of the mass was more prominent, tender to pressure, and presented deep fluctuation. There was considerable periadenitis, the glands being adherent to each other and quite immovable. Examination of heart, lungs, and abdomen negative.

"*Operation, February 12, 1910.*—An incision was made, extending from the mastoid process downward along the anterior border of the sternomastoid muscle to the middle of the neck, then backward, severing the muscle, and continuing downward to the clavicle along its posterior border. The chain of enlarged glands was reached through this incision, and their removal begun from below by clearing the space between the internal jugular vein and the clavicle. The glands and infiltrated gland bearing tissue in this situation were dissected free with some difficulty, but without apparent injury to any of the important structures in the neighborhood. The lower angle of the wound was then tamponed to produce distension of the internal jugular vein, and the dissection of the glands was continued in an upward direction. This was accomplished with a good deal of difficulty, owing to the extensive periadenitis and suppuration in the centre of the mass. It was finally completed, however, and we were about ready to close the wound, when there was a sudden gush of blood from the lower part of the wound behind the clavicle. The haemorrhage was very profuse and came on without the slightest warning, as we had been working in the upper part of the neck and had not touched the lower portion since the beginning of the operation. The flow of blood was stopped by pressure with the fingers behind the clavicle, and the field cleared by sponging. An examination was then made and it was found that the haemorrhage had come from the subclavian artery just internal to the scalenus anticus muscle. By cautiously moving the fingers inward, the outer border of the small opening in the artery was revealed. A haemostat was then placed on the vessel in this situation and two more to the inner side of the first, thus closing the opening. The wound in the neck was now closed in the usual manner, after uniting the cut ends of the sternomastoid muscle with catgut sutures. A drainage tube was placed in the upper part of the wound on account of the secondary infection, and the haemostats were allowed to protrude through the lower angle of the incision.

"Patient was returned to bed in fair condition, with pulse 110 and temperature 100.8° F.

"On February 14th, 48 hours after operation, the haemostats were carefully removed and two moderately firm gauze packings were inserted, one upon the other behind the clavicle and down to the artery. No bleeding occurred immediately after the removal of the forceps, but three hours later the patient had a very severe haemorrhage which stopped spontaneously. The outer packing was then removed and replaced by a firmer one, which was held in position by a tight adhesive plaster drawn across the wound and over the shoulder. After the haemorrhage the patient was anaemic and pulse went up to 118. On February 18th, four days later, there having been no haemorrhage in the interval, the outer packing was removed, but the one next to the artery left undisturbed. The wound looked well, though there was slight purulent discharge from the upper part through the drainage tube. Pulse 112, temperature 101.6° F. Early the next morning, 11 hours after the last dressing, patient had another very

severe haemorrhage. On the 19th he became delirious and on the 20th had two more haemorrhages. From this date until the 25th there were no haemorrhages, his pulse went down to 98, temperature nearly to normal, and we were greatly encouraged about his condition. On February 25th another severe haemorrhage occurred, and between this date and March 4th, a period of seven days, he had 14 haemorrhages of greater or less severity. During this time the temperature ranged from 99.6° to 101° F. On February 27th cultures were taken by Dr. Frank Hinman from the pus in the drainage tube for the purpose of making autogenous vaccines. On this date, slight oedema of the arm and weakening of the radial pulse were noted, the result of long-continued pressure on the subclavian artery [*Sic*]. On March 3d Dr. Hinman injected 150,000,000 bacteria in right arm. On March 4th, condition of patient became so grave that we decided that his only hope lay in the ligation of the first division of the subclavian. This procedure had been considered several times before, but as we had been unable to find in the literature the report of a single successful case of ligation of the first portion in the presence of sepsis, we had looked upon the operation as a last resort. At the time we decided to ligate the artery our patient had a temperature of 103.6° F., pulse 160, and he was delirious from anaemia and sepsis. For five hours before the operation we kept up continuous digital compression of the artery, as the haemorrhage would recur whenever the pressure was released.

"Operation, March 4, 1910, 7.30 p. m.

"Before beginning the operation an intravenous saline transfusion was given in the median basilic vein of the right arm.

"An incision was made along the upper border of the clavicle, from the outer third to the sternoclavicular articulation and then upward for 2½ inches through the old incision along the posterior border of the sternomastoid. An abscess cavity containing several drachms of foul-smelling pus was found beneath the latter muscle. The clavicle was divided with bone-cutting forceps 1¼ inches from the sternum, and the ends retracted in a downward direction, thus giving good access to the subclavian space. Up to this time pressure on the subclavian had been maintained, but when all was in readiness the pressure was released and the packing removed. A gush of blood immediately followed but was at once controlled by direct pressure with the fingers, followed by the application of haemostats to the opening in the artery. The scalenus anticus was next divided, the thyroid axis and vertebral artery recognized, and the subclavian dissected free in a downward direction from the surrounding structures. The dissection was particularly difficult because of the previous operation and the infection of the field, which had caused a matting together of all the tissues. By careful work, however, the subclavian and innominate veins were isolated and drawn forward and the thoracic duct recognized and separated from the artery. After the vessel was completely isolated, two attempts were made to ligate it in the upper portion of the first division, but both ligatures cut through the outer coats and had to be removed. Finally three-quarters of an inch *

* I am surprised to learn that division of the clavicle 1¼ inches from the sternum should have permitted an exposure sufficient to enable the operator to apply a ligature so close to the aorta. (W. S. H.)

above the aorta the wall was strong enough to tolerate a ligature, and a double strand of medium sized silk on an aneurism needle was passed from below upward, behind, and around the vessel. This double ligature was tied in a simple square knot (not the Ballance and Edmunds stay knot) just tight enough to occlude the artery and stop pulsation. A haemostat was then clamped on the vessel about one-quarter inch distal to the ligature. Another double-silk ligature was tied around the artery distal to the opening in its wall and a second haemostat applied proximal to it. The thyroid axis, vertebral and internal mammary arteries were then ligated with silk and the forceps removed from the wound in the subclavian. A loose packing of iodoform gauze was placed in the deep cavity behind the clavicle, the ends of the clavicle united with aluminum bronze wire, and the external wound closed with interrupted silkworm gut sutures.

"When the patient was returned from the operating room, his pulse was 140 and temperature 103° F. For ten days after operation the blood pressure was kept below 112 mm. of mercury by diminishing the amount of ingested liquids and giving spirits of nitroglycerin whenever it reached that point.

"Restlessness was controlled by hypodermics of morphine. Five days after operation the autogenous vaccines were again given and repeated every three or four days thereafter. The temperature ranged from 102.2° F. to 104.2° F. and pulse 120 to 150, until March 19th, 15 days from time of operation, after which both gradually went down to normal. Patient continued delirious at intervals until March 15th. The haemostats were removed from the ligated vessels on March 13th, nine days after operation. On March 13th, he developed a right-sided pleurisy and cough, with yellowish expectoration. His temperature was 103° F. to 104° F. and pulse 130 to 140 for a few days, but the trouble entirely subsided within a week. On March 19th the ends of the clavicle, which had become separated, were reunited. He was allowed out of bed for the first time on March 20th, 16 days after operation. The wound, which was infected at the time of operation, continued to suppurate until the patient left the hospital on April 2d, although it filled rapidly with granulations and was about flush with the clavicle at the time of his discharge.

"The radial pulse disappeared when the artery was ligated and has not returned to date, 16 months after operation.

"The peripheral circulation remained good after the ligation and the hand and arm were warm at all times.

"Marked atrophy of the arm, forearm, and hand took place during the two or three months following operation, and there was great weakness of all the muscles of the left upper extremity from shoulder to fingers.

"Tactile and pain sense were abolished over the lower third of the forearm, hand, wrist, and fingers for four months, and muscular sense in the hand was greatly impaired for the same time.

"As a result of almost constant exercise, frequent massage, and faradic electricity to the weakened and atrophied muscles, the muscular power is now about normal and the muscles have regained their normal volume and tone. There still remains, however, slight impairment of tactile sense in the tips of the fingers. The general health of the patient at the present time

is perfect, weight up to normal, and he is able to attend to his regular business affairs."

Dr. Neff is to be congratulated on his rare good fortune in not losing the patient, and thanked for courageously narrating unhappy experiences which so clearly convey messages of warning.

The major errors in Neff's case were (1) the leaving of haemostats hanging in the wound; (2) the attempt to control the infection of the wound by vaccination rather than by antiseptics; (3) the postponement of operation for the arrest of bleeding until, after about a score of secondary haemorrhages, the patient had become exsanguinated; (4) the ligation of the branches of the first portion of the subclavian (thyroid axis, vertebral, internal mammary) unless, as the author probably believed, the condition of the subclavian precluded ligation. The operator should consider how the closure of an artery permanently clamped in continuity may be accomplished. Surely the intimal surfaces which cannot adhere under ligature or band even when brought together in the gentlest manner cannot do so when compressed under a crushing haemostat. Nor can organization of the remaining shreds of the arterial wall take place under the spring of the clamp. In the absence of infection the artery may be sealed by endothelial proliferation and by adhesion, perhaps, of the intimal surfaces held in contact for a short distance on both sides of the clamp. In the presence of infection the closure may, of course, be effected by the organization of a thrombus.

Hans Rubritius. (XIV.) *Die chirurgische Behandlung der Aneurysmen der Arteria subclavia.* Beiträge z. klin. Chirurgie, Tübingen, 1911, Bd. lxxvi, p. 144.

"P. L., aet. 21, laborer. Entered the Prague Clinic October 2, 1909. On September 13, 1909, he was stabbed in a brawl in the left side of the neck. Violent bleeding followed, which was controlled by a firm bandage. Later he was brought to the dispensary, where Primärarzt Dr. Rösler observed that there was virtually no bleeding, but there was a high grade of anaemia. As no haemorrhage occurred in the days following, the wound was simply dressed aseptically. September 20, 1909, on changing the dressing, a considerable swelling was noticed in the left supra-clavicular region, in which in the following days a pulsation developed. On the assumption that it was a case of false aneurism of the carotid, Dr. Rösler sent the patient to the clinic.

"*Examination.*—Middle-sized man, well nourished. Lungs and heart sound. In the left supraclavicular region there is a pulsating tumor the size of a fist, at the summit of which, close to the outer edge of the left sternomastoid, there is a scar about 1 cm. long. On auscultation there is heard over the tumor a systolic bruit, which is also audible over the axillary artery. The left radial pulse is weaker than the right. Blood pressure measured

with the Gärtner tonometer is, right, 70-75 mm. Hg., left, 60-65. The left arm is slightly cyanotic, but there is no swelling or dilation of the veins. Movements in the left shoulder joint are somewhat impeded.

"*Diagnosis.*—False aneurism of the left subclavian artery.

"*Operation I, October 5, 1909.*—Anaesthetic, Billroth mixture. Length of operation 1½ hours. Skin incision over the tumor downwards to the middle of the clavicle, which was cut through in its centre with a Gigli saw. It now developed that the aneurism was situated very far central on the subclavian, indeed in its middle portion. In order to approach the artery so that it could be ligated central to the aneurism, the sternal half of the clavicle was completely removed, and a piece of the first rib about 4 cm. long was resected; also the left half of the manubrium had to be taken away. Now for the first time it was possible to reach the central pole of the tumor and to expose the artery at its origin. In dissecting the artery the pleura was wounded, and with a hissing sound pneumothorax developed. Carefully protecting the very full subclavian and jugular veins, between these two vessels with the aid of a curved foreign-body forceps a thin rubber tube was drawn around the artery. The ends of the tube were now made fast to a probe about 20 cm. long in order that by twisting the probe the tube might be gradually tightened, and thus by degrees compression of the artery be brought about. Tampon of the large wound; dressing.

"In the course of the next 24 hours the probe was twice rotated through 180 degrees.

"*Operation II, October 27, 1909.*—Examination shows that the pleural cavity is distended with air and the heart completely pushed to the right. The tumor in the left supraclavicular region now pulsates no longer. At the point where the rubber tube had been two strong silk threads were placed around the subclavian artery, thus doubly ligating it.

"Some days thereafter there appeared an exudate in the pleural cavity; at first only blood was obtained by aspiration; as this soon became fetid an operation was undertaken on November 15th. An incision 10 cm. long was made between the 7th and 8th ribs, a piece of the 8th rib resected, the pleura opened and drained with a rubber tube.

"November 16, 1909, drain removed from the pleura. The wound resulting from the first operation decreased gradually; at the site of the aneurismal tumor one feels a firm mass. The left radial pulse is not palpable; the left arm shows muscular atrophy, but except for this there is no disturbance of motion. . . . . The patient was discharged December 1, 1909.

"On December 10, 1909, Herr Primärarzt Dr. Rösler stated that the patient, a few days after his discharge from the clinic, again made application to be admitted to the Aussiger Spital. On admission it was found that he had fever and that the entire left half of the thorax was dull. Soon thereafter a great quantity of foul-smelling pus emptied itself spontaneously out of the wound from which the rib had been resected. A drainage tube was again inserted. According to a further communication on April 18, 1910, from Dr. Rösler the secretion still persisted, hence he was again admitted to our clinic.

"*April 19, 1910.*—The patient is found to be greatly emaciated and anaemic. The left lung is markedly retracted, pulmonary resonance is pres-

ent only to the middle of the scapula. In the posterior axillary line at the level of the 8th rib there is a fistulous opening which leads far into the pleural cavity and from this a purulent secretion runs continuously. Accordingly, on the 25th of April a thoracoplastic operation was done. After reflecting a great flap, 8 or 10 cm. of the 7th, 8th, 9th, and 10th ribs were resected, and the skin-flap turned into the great hole. Not until the middle of June did the secretion begin to decrease. On the 30th of June the wound was completely healed and the patient was discharged."

No statement is made in regard to the fate of the haematoma. Presumably it became infected and was thus dissipated.

The case of Rubritius is another to emphasize the importance of closing wounds, and not only those made for the ligation of large arteries. It was clearly an error in the first instance to have undertaken to occlude gradually the subclavian artery of a youth and, particularly so, by a method which prevented closure of the wound. I have found no evidence, after a careful survey of all the recorded cases, to sustain the fear that gangrene may follow the uncomplicated ligation of any portion of either subclavian artery; there was, therefore, no indication for the attempt to occlude the artery gradually, and particularly none by a method which superimposed the danger from infection—to the wound, to the artery, and to the opened pleural cavity. The gangrene which followed the difficult and brilliantly executed operation of Matas [35] for arterio-venous fistula of the right subclavian vessels seems quite unquestionably to have been chiefly due to the derangement of the arterial and venous flow incident to the fistula. The ligation of the branches of the first and second portions of the artery may also possibly have been a determining factor.

Although sternly disapproving of the method pursued by Rubritius in the management of his case, I can endorse in greater part his generalizations in respect to the treatment of subclavian aneurisms:

"We believe that one should always first test the central ligation; if this intervention has been simple and accomplished in a short time one may proceed to make a peripheral ligation and perhaps an incision into and a clearing out of the aneurismal sac. If the operation has been difficult and the condition of the patient such that one dare not venture to do more, the surgeon should rest content with the central ligation.

"Usually this operation alone will accomplish the desired result. When not, then must one at a second operation make the peripheral ligation and incise the aneurism. This is the operation which Hofmann * proposed at the initiative of von Mikulicz. We believe that this latter procedure deserves serious heeding under the pictured circumstances; and contrary to the views

* "H. Hofmann. Zur operativen Behandlung d. Aneurysmen. Beitr. z. klin. Chir., Tüb., 1899, xxiv, p. 418."

of v. Frisch * and Saigo,† who advise extirpation in every case, we would pronounce the central ligation as the operation of choice in the treatment of subclavian aneurisms, as already Oberst ‡ and Rotter § have done."

G. P. Newbolt. (XV.) *A case of aneurism of the second and third parts of the left subclavian artery in a woman.* British Medical Journal, London, 1912, vol. ii, p. 867.

"Miss E., aged 50, consulted me on February 3, 1912, concerning a pulsating swelling at the root of her neck on the left side which filled up the hollow above her collar-bone. This swelling had existed for three years in spite of treatment. It pulsated and the pulsation was distensile. The swelling involved the second and third parts of the left subclavian artery and the tumour extended into the axilla, where it could easily be felt. At one place above the collar-bone the swelling seemed to be just under the skin and threatened to come through. The inner margin extended well under the outer border of the sternomastoid muscle. . . . . Her doctor (W. H. Carse, of Rochdale) informed me that she had had marked endarteritis three years ago, when the vessels of her right arm were affected and her right radial pulse disappeared."

The patient was admitted to the Royal Southern Hospital March 2, 1912.

"On March 14th I tied the first part of her left subclavian artery.

"An incision 6 or 7 inches long was made down the line of the sternomastoid on to the sternum, taking the sternoclavicular joint as the centre of the incision. A second incision was made at right angles to the first extending along the collar-bone. Flaps were turned up and the collar-bone was exposed at its inner end. This structure was cleared by dividing the clavicular portion of the sternomastoid, and a rib elevator was passed under it, followed by a Gigli's saw, with which the bone was divided, the sternal end being turned inwards and dissected out. A small vein connecting the internal and external jugulars was tied, but there was practically no bleeding. The sternohyoid muscle was defined with dissecting forceps and partially divided. The internal jugular was very large and there was a high innominate junction, so that these veins practically filled the floor of the wound. By working down on the inner side of the internal jugular, the common carotid was exposed with the pneumogastric nerve lying on its outer side and behind. The big veins were now retracted downwards and outwards, and by drawing the carotid to the inner side the subclavian was felt pulsating deep down between the two. A vein crossing this space was tied, but the inferior thyroid vein was left untouched, and by scraping down

* "Otto v. Frisch. Beitrag zur Behandlung peripherer Aneurysmen. Arch. f. klin. Chir., Berlin, 1906, lxxix, p. 515."

† "K. Saigo. Traumatische Aneurysmen im Japanisch-Russischen Kriege. D. Zeitschr. f. Chir., Leipz., 1906, lxxxv, p. 577."

‡ "Oberst. Das Aneurysma der Subclavia. Beitr. z. klin. Chir., Tüb., 1904, xli, p. 459."

§ "Rotter. Zwei Fälle von traumatischen Aneurysma. Zentralbl. f. Chir., Leipz., 1906, xxxiii, p. 783."

with a blunt dissector the artery was exposed for a space of about three quarters of an inch. The sheath was opened and the vessel found to be quite healthy. An aneurysm needle was passed from the inner side armed with a catgut ligature, and by means of the latter a loop of thick silk was drawn under the vessel. The latter was secured by tying the silk in two places with just enough force to occlude the vessel without damaging its coats. These ligatures were placed one-half inch apart, but one end of each was left uncut, and these were tied together. A reef knot was used. Pulsation at once stopped in the aneurysm. The wound was closed without drainage, but the cavity was obliterated as much as possible by bringing divided structures together. The arm, which was quite warm, was wrapped in cotton-wool.

"The operation took 40 minutes, but was not hurried over, and it was not as difficult as might have been expected. . . . . There was no haemorrhage. The vessel lay very deep at a distance of from two and a half to three inches from the surface. . . . . The subsequent history was uneventful as far as recovery went.

"On the 15th she was very well, and her right carotid pulse was 84; no pulsation could be felt in the left radial, but her fingers were warm, and she moved them easily. There was no tingling of the fingers. . . . . On the 16th she complained of a little pain down the left arm. On the 21st . . . . she had only a little tingling in her fingers. March 23d . . . . the stitches were removed; the wound had healed, and the sac was hard and did not pulsate; she felt quite well and wanted to sit up. On April 5th . . . . the aneurysmal swelling was smaller and decidedly softer, but there was no pulsation, and the swelling in the axilla was much smaller; there was no pulsation in the radial at the wrist. On April 15th there was a small ulcer over the lower part of the scar on the chest, and this was dressed. The swelling in the neck now felt like a soft cyst, and the axillary sac was smaller and harder. . . . .

"On May 10th she returned home, exactly eight weeks after ligature of the vessel, there being no sign of pulsation in the sac, which was rapidly disappearing. She was able to raise her arm fairly well, and could place her hand to the back of her head. The small ulcer on the scar had practically healed. On June 8th I saw her; she was very well, and her only trouble was the limitation in the power of abduction. The aneurysm had practically disappeared, but her left hand was decidedly colder than her right. . . . .

". . . . This successful case is, of course, well known as the first, if not the only one, in this country. The vessel has, I believe, been tied by Halsted, J. K. Rodgers, and by Schumpert, but I am not familiar with the results of these cases. . . . ."

Mr. Newbolt erred in believing that he was the first, in his country, to ligate the left subclavian artery in its first portion. Stonham reported a successful case in 1902 (*l. c.*, no. IX), and Browne another in 1911 (*l. c.*, no. XII). Sir Wm. Banks attempted the ligation in 1903 (*l. c.*).

Professor Wieting. (XVI.) *Die Unterbindung der Arteria subclavia sin. in ihrem I. Abschnitt.* Zentralblatt f. Chirurgie, Leipzig, 1912, Bd. xxxix, p. 1156.

P. 1157. "Aneurysma spurium traumaticum A. subclaviae durch S-Geschoss."

"December 26, 1911. The patient, male, aet. 35, ... was shot in the left shoulder, the projectile entering the back at the upper inner angle of the shoulderblade. He immediately coughed up blood and was referred to the first aid military dressing station, whence two days later he was sent on foot to Gülhane, arriving in a weakened condition.

"*Examination.*—The entrance wound, about 1 cm. in diameter, is inflamed at the edges, and is situated behind at the upper inner angle of the left shoulderblade. There is no exit wound. The X-rays show the projectile behind about the middle of the clavicle. Above and on the clavicle, beginning about 3 cm. from the left sterno-clavicular articulation and reaching to the shoulder joint is a strongly pulsating tumor, about half the size of a goose egg. Ecchymosis extends over the whole left side of the neck to the nape, and downwards on the thorax to the pelvis. The pulsating swelling extends far into the depths towards the back, and can be felt to within a few centimeters of the entrance wound. The external jugular vein is visibly dilated. The radial pulse is absent, otherwise the nutrition of the arm, with the exception of slight venous hyperaemia, is not disturbed. But there is complete paralysis of the left arm up to and including the shoulder, while sensation is intact. The patient complains of shooting pains in the left arm.

"A few times there was expectoration of bloody sputum, but this has ceased. The left side of the thorax is completely filled with blood. General condition is tolerably good.

"*Diagnosis.*—Gunshot wound of the left subclavian artery above the clavicle with traumatic spurious aneurism; whether the subclavian vein is also wounded cannot be determined. Compression and perhaps partial laceration of the brachial plexus; wound of the left pleural apex and lung and a left-sided haemothorax.

"A compressive bandage was applied in order to promote the formation of collateral circulation. The pressure had no favorable influence on the aneurism itself; on the contrary, it was extending towards the skin and towards the back, and also somewhat medially. Rupture through the skin, which is very thin over the tumor, appears imminent. Indication is vital.

"The plan of operation is to reach the left subclavian artery central to the aneurismal sac, to clamp it temporarily, and then to remove the haematoma, in order, if feasible, to close the wound in the vessel.

"First of all, it was intended to search for the left subclavian artery near its origin from the arch of the aorta, using the common carotid artery as a guide. The internal jugular vein must be sacrificed, the vagus nerve and the thoracic duct must be spared. The space central to the aneurism is small, hardly 3 cm. broad, therefore it is best to resect the clavicle centrally, in order to make room.

"In order to establish blood depots the veins of both legs and of the left arm were occluded by a constricting bandage. The right arm was left free for pulse control and a possible infusion.

"*Operation, January 4, 1912.*—Incision over the left sternoclavicular joint, beginning on the right at the inner end of the right clavicle; on the left, ending temporarily before the aneurism. Dissection of the left sternomastoid, and of the sternolaryngeohyoid-bone muscles with ligation of the

neighboring veins. In the depths one can feel the pulsating dome-like sac projecting outwards and backwards. The external jugular vein, greatly compressed and thrust forward, was doubly ligated. Now the median end of the left clavicle was snipped off in pieces for 2 cm. with the cutting forceps, since, from behind, the aneurism left no space. In the same way, starting at the sternoclavicular joint, a piece of the sternum was removed. Thus, the common carotid, the vagus nerve and the innominate vein were well exposed. The V. jug. comm.—huge at this point—was doubly ligated with celluloid thread 1 cm. above its junction with the subclavian vein and divided; the left vertebral vein was treated in the same manner. Now the subclavian artery, ascending in an arch, was well exposed. The thoracic duct was left outside and above, lying close to the aneurism. The common carotid artery with the vagus nerve was drawn strongly inwards with a blunt retractor, the innominate vein downwards. Compression of the ascending portion of the subclavian artery caused all pulsation in the aneurism to cease; for this reason a thick celluloid thread in a Deschamps needle was temporarily placed around the artery and a half knot made so that in case of need it could be drawn taut. The temporary clamping was done with the rubber-covered artery clamp of Höpfner-Stich.

"The skin incision was now lengthened superficially outwards to the shoulder, and the aneurism, which lay close under the skin, was opened wide. The projectile lay, dull end foremost, not far behind the clavicle near the inner edge of the sac. About 300 c. cm. of spongy black coagulum and fluid blood were evacuated with the finger from a cavity which was deep, extending almost to the nape, and behind the clavicle and first rib. . . . . From the walls of the aneurismal sac there is moderately abundant arterial and venous bleeding, so that exploration of its great cavity is difficult. As the condition of the patient would not admit of prolonging the narcosis in order to search for the site of the wound, and since sewing it up at the great depth, although certainly possible, would be very uncertain and time-consuming, it was abandoned. The ligature around the subclavian artery was tied and this wound entirely sewed up. The aneurismal sac was firmly stuffed with gauze and the overlying skin temporarily closed. Pressure bandage over the wound.

"After the operation the patient was soon in good spirits. There was no cerebral disturbance. The left arm remained nourished as formerly. As the ligation was done central to the vertebral artery and the thyroid axis and likewise the internal mammary, the collateral circulation was assured.* The pains in the left arm diminished. Unfortunately on the following day marked paresis of the right arm was noticed, which was referable to the compression of the pressure-bandage on the right plexus. This paralysis, of which that of the radial nerve continued the longest, soon subsided.

* An incorrect assumption, it seems to me, for the enumerated branches of the first portion had been blocked on both sides, centrally by the ligature and distally by the stuffing in the aneurismal sac. A ligature applied distal to the origin of these branches would less have imperiled the circulation of the arm. The circulation would nevertheless be carried on by the anastomoses of these branches of the first portion of the subclavian. The closer the ligature, central or peripheral, to the sac the better. (W. S. H.)

"On the 8th day the outer stitches over the tampon were removed without haemorrhage. The great cavity is clean. New light tampon with iodoform gauze. January 13, 1912. Very light tampon with new compress bandage. The left arm is somewhat swollen from too tightly drawn bandage. January 16, 1912. The cavity is fast getting smaller, principally through expansion of the lung. In front pulmonary resonance, behind, dullness to the spine of the scapula.

"Two months after operation the patient left the hospital with the wound healed. Pulse in the radial artery is still absent. Motility in the left arm is slowly returning; fingers and elbow can be moved. Further news of the patient not obtainable."

The day is, I trust, near when to pack a wound in order to arrest haemorrhage except under compelling circumstances will be considered reprehensible.

V. Gaudiani. (XVII.) *Ligation of the first part of the left subclavian for aneurism.* Medical Record, New York, 1915, vol. lxxxvii, p. 331. New York Academy of Medicine. Stated meeting, held January 8, 1915.

"Dr. V. Gaudiani presented a man, 46 years old, who came under his care in May, 1913. He had had luetic infection 20 years before, but had never taken any treatment. A few months before he had noticed a pulsating tumor of the size of an egg rising from the sternal notch and extending behind the sternocleidomastoid muscle. He did not show any other trouble with the exception of an area of anaesthesia on the inner side of the forearm, and a dilatation of the left pupil. A murmur could be heard over the tumor; this was also audible along the axillary vessels. Although the case had been considered an inoperable one, Dr. Gaudiani advised a central ligation of the subclavian. The operation was performed under intratracheal insufflation to prevent possible pneumothorax. An incision was made from the manubrium of the sternum, curving upward over the sternocleidomastoid muscle, and reaching down the outer extremity of the clavicle. Such an incision was decided on because it would permit eventually the resection of the sternum or clavicle and allow also a peripheral ligature in case the central was not feasible. After the muscle had been cut through, the tumor appeared covered by the internal jugular and by the upper part of the vena anonyma. The former was ligated and severed and the latter was gently pulled down. By means of blunt dissection it was possible to penetrate behind the sternum, along the carotid, until central compression of the aneurism was possible. Such compression stopped the pulsation in the sac and the radial pulse. A silk ligature was passed and a stop knot was made. The patient made a good recovery and he could now attend to his duties in iron foundry work. No radial pulse could be felt. The stretching and isolation of the subclavian loop of the sympathetic nerve, known as the ansa Vieussensi, which surrounded the sac, could explain the mydriasis of the left pupil."

The aneurism seems to have been of the first portion of the subclavian; presumably no branches were given off between the ligature and the prox-

imal pole. The patient made a good recovery and resumed work in a foundry. Nothing is said about the fate of the aneurism. He was observed seven months or less.

Carl A. Hamann. (XVIII.) *Ligation of the first part of the left subclavian artery.* Annals of Surgery, Philadelphia, 1918, vol. lxviii, p. 219.

"E. R., aged 50 years, had an aneurism about 1 inch in diameter, involving the third portion of the left subclavian artery, which had been noticed for about one year; there were no marked evidences of pressure on the vein or nerves, though he had some pain. Wassermann reaction negative. There was a moderate degree of arteriosclerosis and the arch of the aorta was somewhat dilated.

"He was operated upon at Charity Hospital May 10, 1917.

"The third portion of the artery was exposed by the usual incision, and it was found that the dilatation extended beneath the scalenus anticus; this muscle was, therefore, divided after displacing the phrenic nerve. The subclavian and internal jugular veins and thoracic duct and vagus nerve were held aside and the first portion of the artery well exposed; it was somewhat dilated. A double ligature of braided silk was passed around the vessel and firmly tied. Pulsation in the sac ceased at once and did not return.

"The wound healed *per primam* and no disturbances in the circulation of the upper extremity, except for the absence of the pulse beyond the ligature, ever appeared. The sac contracted into a small firm mass and when last seen, four or five months afterwards, the patient was quite well.

"In this case the branches of the subclavian were not tied, as has been suggested and practised by a number of surgeons, in order to lessen the dangers of secondary haemorrhage."

Dr. Hamann did well to refrain from tying the branches of the subclavian. The danger of secondary haemorrhage is practically nil in the absence of infection and if the ligation is properly performed.

The first portion of the subclavian was so easily and so well exposed that it would seem to have coursed high in the neck. It is interesting to note that the artery was somewhat dilated at the site of the ligature. We have, I think, good reason to believe that the danger of ligating dilated or diseased arteries is overestimated. I have twice successfully ligated a dilated innominate artery, and Col. J. S. White has ligated the base of an aneurism without mishap (*vid.* Case No. XIX of our table).

J. Sinclair White. (XIX.) *Traumatic aneurism of the left subclavian artery: successful ligation at the junction of the first and second portions.* British Medical Journal, London, 1918, vol. ii, p. 131.

"The treatment of aneurysm of the left subclavian artery by ligature of the vessel always presents considerable difficulties, which are the greater the nearer the ligature is applied to the origin of the artery. From the experi-

ence of the following case, I have been led to draw certain conclusions, which are set out at the end of the report.

"Pte. M., aged 35 years, sustained a gunshot wound of the chest on August 16, 1917, at Ypres. The bullet entered behind to the left of the third dorsal vertebra and escaped just above the clavicle at a point corresponding to the junction of the middle and inner thirds of the bone. He spat blood for a day or two afterwards, but the wound progressed favourably, and on August 30th he was transferred to England. By September 3d his wound was soundly healed. There was partial paralysis of the left deltoid muscle, for which daily massage and galvanism were prescribed. He continued to pick up until November 16, when a pulsating swelling appeared at the root of the neck. It had all the characters of an aneurysm, and as it steadily increased in size, Colonel A. M. Connell, assisted by Major E. F. Finch, operated on December 8th. The swelling proved to be a saccular aneurysm arising from the second part of the subclavian artery. Owing to the dense matting of the tissues around the aneurysm the placing of a proximal ligature was not attempted. Instead a stout catgut strand was tied around the base of the aneurysm where it sprang from the upper convex margin of the artery.

"This procedure was for a time followed by marked improvement, and both swelling and pulsation almost entirely disappeared. Then the aneurysm began to enlarge again, and by the end of December it had become obvious that, unless something further could be done, it was merely a question of how long he would live. In view of its position and the knowledge that one would have to conduct a deep dissection through tissues distorted by inflammatory exudate and containing vessels and nerves of the first importance, further operative measures could not be lightly entertained, but, as the alternative seemed wholly black, the facts of his case were placed clearly before him, and he elected to be operated on a second time. The operation took place on January 2, 1918, under chloroform anaesthesia given by Captain N. Milner. I had the valuable assistance of Major G. Wilkinson and Major E. F. Finch.

"*Operation, January 2, 1918.*—The steps of the operation were: (1) Removal of the scar of the first operation, together with some unhealthy granulation tissue. (2) Subperiosteal resection of the inner half of the clavicle. The sternal attachments of the bone were not divided, and the decorticated bone was made to pivot over to the right after being surrounded by gauze. (3) A long and tedious dissection involving the ligation and division of several veins, injury to the thoracic duct or one of its branches, from which much milky fluid escaped, and identification of the subclavian and internal jugular veins and the lower part of the scalenus anticus muscle. (4) Careful division of the scalene muscle with a small scalpel from without inwards. The fibres were divided close to the rib and very cautiously, taking especial care not to encroach on the anterior or internal portions of the muscle sheath. (5) The subclavian artery at the junction of its first and second portions was ligatured with a double strand of No. 1 Van Horn's catgut after it had been ascertained that occlusion of the artery at this point controlled the circulation in the aneurysm. (6) The displaced portion of the clavicle was fixed in position by strands of catgut passed through

holes drilled in the bone, and the extensive wound closed by a series of superimposed catgut sutures, a small rubber tube being left in for 72 hours.

"Aseptic healing followed, and beyond a small mass of cicatricial tissue no local evidence of the aneurysm can be discerned.

"I am indebted to Captain J. E. Stacey for the notes of the case.

"The lessons which I have learnt from a study of this case are:

"1. To be prepared to meet with extraordinary difficulty in exposing the artery on account of inflammatory exudate caused by the bullet or shell fragment.

"2. The value—indeed I might say the necessity—of resecting the clavicle in order to secure adequate room.

"3. The advantage to be derived from dividing the scalenus anticus muscle in the way I have described. By the judicious use of small retractors after its division it is possible to draw inwards the phrenic nerve and to displace the pneumogastric and sympathetic nerves, together with the other important structures lying to the inner side of the muscle, and so reach the distal part of the first portion of the artery."

Should this case be regarded as a ligation of the first portion of the artery? To question it is perhaps to quibble. Inasmuch as the clavicle and the scalenus anticus muscles were divided, it would have been quite as easy to ligate the artery definitely in its first portion unless the superior intercostal branch were just proximal to the site of ligation. In any event the operator did well to ligate, as I presume he did, distal to the superior intercostal artery and as close to the aneurism as feasible.

Sir Charles Ballance. (XX.) *A case of ligation of the first part of the left subclavian artery.* Journal of the Royal Army Medical Corps, London, 1918, vol. xxxi, p. 417.

"Private K., Dublin Fusiliers, aged 31, was admitted to Cottonara Hospital, Malta, under the care of Lieutenant-Colonel Dundon, R. A. M. C., on January 13, 1918, from Saloniki.

"*History.*—Before joining the Army he had been in the Navy, from which he was discharged; reason unknown. No history of syphilis. In July, 1916, he was wounded by a shrapnel bullet in the left supraclavicular region. The wound was just above the middle of the clavicle and had healed. He had recently had an attack of tertian malaria.

"*On Admission.*—Patient complains of numbness and shooting pains in the left arm and hand with muscular weakness. A well pulsating tumour can be seen and felt above the left clavicle; an area of dullness continuous with this swelling extends for two inches below the inner half of the clavicle. The radial pulse can only just be felt at the wrist but the arm is quite warm. X-ray examination shows the presence of a tumour, part of which is in the chest cavity, and the rest, curving over the first rib, extends into the root of the neck. It seems more dense in the lower part, probably on account of organized blood clot in the aneurysmal sac. A shrapnel bullet is lodged in the right side of the chest at the level of the seventh rib. It has not been definitely localized as there is no likelihood of its being removed. A diagnosis of aneurysm of the second and third portions of the left sub-

clavian artery was made and it was decided to ligate the subclavian on the proximal side of the aneurysm. Antisyphilitic remedies had no effect.

"*Operation, February 4, 1918.*—A general anaesthetic was given by Lieutenant-Colonel Shirley with the Vernon-Harcourt apparatus. An incision was made along the anterior border of the lower half of the sternomastoid down to the manubrium and another horizontally along the inner half of the clavicle. The common carotid artery, internal jugular vein, and vagus nerve were exposed in the middle of the neck and the dissection was continued downwards, keeping well towards the middle line of the neck, as the wall of the aneurysm extended in this direction and was very thin. The fingers of the left hand protected the wall of the aneurysm from injury. More room was required, so the inner third of the clavicle was resected, by division with a Gigli saw and disarticulation at the sternoclavicular joint. The dissection became increasingly difficult, the aneurysm and internal jugular vein had to be gently pressed outwards with the fingers while the common carotid artery and vagus nerve were retracted inwards with a copper retractor. The deeper part of the tumour was nearer the middle line than the superficial part; the vessel had probably been injured at the junction of the first with the second part, and the aneurysm had developed in front of the artery and displaced it and the dome of the pleura backwards as it increased in size. It had extended below the first rib through the upper opening of the thorax. At last the vertebral vein was recognized and behind it the artery was both seen and felt. It was cleared and ligated with three medium-sized strands of kangaroo tendon tied in a stay knot. Pulsation in the aneurysm immediately ceased. The patient left the table in good condition. I was admirably assisted in the operation by Captain James Anderson, R. A. M. C.

"*Progress.*—No untoward symptoms followed the operation and the wound healed throughout by first intention. Five weeks after operation the patient had an attack of malaria; tertian parasites were found in the blood. Tartar emetic (0.04 to 0.12 gramme) and quinine bihydrochloride (15 grains) were injected intravenously on alternate days. The fever did not recur.

"Radiograms taken after the operation show progressive consolidation of the aneurysm. This is most marked in the upper part. Before operation the part above the clavicle showed no defined border but only a fluffy edge from the constant pulsating movement during the exposure of the plate. In the later photograph taken some time after the operation this upper part shows a well-defined outline.

"With the contraction of the aneurysm the pain and weakness of the upper extremity exhibited week by week progressive improvement.

"No evident inconvenience resulted from the loss of the inner third of the clavicle; the arm, when he left the hospital, was in excellent condition and could be moved in any direction. The clavicle became fixed to the first rib.

"The rarity of ligation of the first part of the left subclavian gives an interest to this case."

W. S. Halsted. (XXI.) (Pages 487 to 491.)

Sir William H. Banks. *Unsuccessful attempt to ligate the first portion of the left subclavian artery.* Liverpool Medical Institute. Meeting of December 18, 1902. Lancet, London, 1903, vol. i, p. 103.

"In the second case degeneration of the artery was unlikely, as the patient was a young, healthy man, the condition being due to a railway crush. The aneurysm had spread into the neck and was as much subclavian as axillary. With the aid of his colleague, Mr. Paul, Sir William Banks made a strenuous attempt to ligature the first part of the left subclavian artery in the thorax; the pleura was a good deal injured and the patient died from pleurisy."

The above is the entire memorandum.

J. Garland Sherrill. *Report of a case of aneurism, with a new method of ligature of the left subclavian.* Transactions of the Southern Surgical and Gynecological Association, 1911, vol. xxiii, p. 190.

"In January, 1910, a colored man, aged 30 years, was admitted to the hospital; family history negative; . . . . chills and fever at the age of 19. . . . . He had had occasional pain in the chest since August, 1908. . . . .

"In August, 1909, he was injured in the subclavian region of the left side by a wagon crank; followed within one month by a swelling in the same region, which remained a few weeks and became smaller; to be followed in a short time by another enlargement in the same region, which also remained about a month and became smaller. The present tumor began to enlarge about December 15, 1909, and had gradually increased in size. . . . . At present he complains of pain and tenderness in the left shoulder, also suffers tenderness just above the spine of the left scapula and in the left axilla.

"When I first saw him about January 1, 1910, he had a pulsating tumor about the size of a small melon situated at the upper part of the thorax, extending from near the median line and just above the level of the clavicle downward and outward almost to the margin of the pectoralis major muscle. This tumor pulsated synchronously with the heart and was distinctly expansile in character. No distinct bruit could be heard over the tumor, but an accentuated second sound of the heart was easily detected. The patient had an almost imperceptible pulse in the left radial, and it was delayed somewhat compared to that of the right radial. The pulse of the left carotid was synchronous with that of the right radial. Patient had no tracheal tug; had no marked dyspnoea, although he was more comfortable sitting up in bed. He had no cough and no interference with deglutition or respiration. A diagnosis of subclavian aneurysm was made, and the various methods of treatment were discussed with the patient and with several physicians in attendance.

"Distal ligation of the subclavian was considered inadvisable owing to the distance the tumor extended out upon the chest, and also because we believed that this measure would not prove curative. Ligature in the first portion anteriorly was not to be considered owing to the position of the tumor, which would have interfered greatly with the accomplishment of

that step. After discussing the merits of wiring the sac and the possibility of complete cure if we could successfully ligate the subclavian in the first portion of its course by attacking it from the posterior surface of the thorax, the patient decided to accept the latter method.

"*Operation.*—On January 27, 1910, the subclavian was tied a short distance from its origin at the aorta. The operation was performed in the following manner: An incision was made along the posterior margin of the scapula about four inches long, dividing the skin and the muscles attached to the posterior portion of this bone. It was joined by an incision running inward from its inferior extremity to the spinous process. A similar incision was carried from its upper end in towards the spine. The soft tissues were dissected from the ribs with the skin and all haemorrhage controlled. The second, third and fourth ribs were removed for a distance of about three inches. The intercostal muscles were lifted off the pleura; the latter was gently pushed downward and outward with the finger, and the subclavian artery readily came into view as it left the aorta at the level of the fourth dorsal vertebra. A small opening was made in its sheath and the needle was readily carried around it and a No. 3 catgut ligature placed in position. At this point of the operation it was discovered by the assistants that the pulsation in the aneurysm did not cease. We then discovered, much to our disappointment, that the diagnosis as to the location of the aneurysm had not been correctly made. Further search revealed below the origin of the subclavian a rounded mass seemingly not larger than a small orange, which was pulsating. On discovering this, we decided that the ligature upon the subclavian, being useless, should be removed. This having been accomplished, the wound was closed and the patient left the table in good condition, and within an hour he was conversing freely with the attendants in the ward.

"Patient died February 7, 1910, on rising up suddenly in bed to eat his meal, although positively ordered not to make any sudden exertion. The postmortem demonstrated an aneurysm of the arch of the aorta in its lower portion, which had ruptured into the esophagus."

Interested in the unique and clever operative procedure and the puzzling and misleading physical signs, I wrote to Dr. Sherrill, who kindly replied as follows: "My case of ligature of the left subclavian was based on an incorrect reading of the skiagram and also on the fact that the pulsating mass was situated in the upper portion of the left chest over the site of the subclavian artery. There was present in this case a sacculated aneurism of the thoracic aorta which had a secondary sac extending upward and forward, and this simulated aneurism of the subclavian. To produce this secondary sac there must have been a small rupture and the wall of the secondary sac was found to be made up of connective tissue."

No.	Operator and publication	Sex and age	Description of tumor	Symptoms	Operation	Result	Comments
I	Rodgers, J. Kearny. Case of ligature of the left subclavian artery within the scalenus muscle, for aneurism. N. Y. Jour. of Med. & the Collateral Sciences, 1846, vii, p. 219.	M. aet. 42.	Pulsating tumor, above the clavicle about the size of a hen's egg; it extended externally to the outer third of the clavicle and internally was covered by the outer edge of the sternomastoid. Cutaneous veins below sternal end of clavicle much enlarged.	Pains from axilla to finger-tips, so severe that patient cannot rest. Whole upper extremity swollen. Radial pulse unaffected.	Oct. 14, 1845. Tumor overlapped outer half of scalenus anticus. Subclavian artery ligated just internal to the scalenus muscle.	† Died on 15th day. Suppuration; secondary haemorrhages on 13th, 14th and 15th days.	May not the fact that the radial pulse was unaffected account in part for the great swelling of the arm in this case in which the aneurism was so small?
II	Marchesano, V. Legatura della succlavia sinistra fra la trachea e gli scaleni. L'Osservatore med., Palermo, 1875, s. 3, v, p. 327.	M. aet. 34.	Profuse bleeding from wound made with a sharp instrument (chisel) a few hours before the operation.	Haemorrhage	July 17, 1875. Division of the sternal and part of the clavicular portions of sternomastoid and of the inner half of scalenus anticus. Ligation of left subclavian artery about at junction of the first and second portions. Size and material of the ligature not stated.	† Died July 24 from "tremendous" haemorrhage.	Autopsy: The final haemorrhage had come from the subclavian at the site of the ligature which had cut completely through the vessel and had been applied distal to all the branches of the first portion. The posterior and suprascapular arteries sprang from a common trunk distal to the ligature. The original haemorrhage had come from the posterior scapular which had been cut with the chisel. No mention is made of the superior intercostal artery.
III	Lane, L. C. Ligations done for the cure of aneurism. Pacific Med. & Surg. Jour., San Fran., 1883-1884, xxvi, p. 145. Case II, p. 149.	M. age not stated.	Tumor two-thirds the size of a fetal head.	None given	No dates given. Op. I.—Ligation between the scaleni muscles, closed wound. Op. II.—Two weeks later, for control of secondary haemorrhage, subclavian artery ligated proximal and close to the aneurism and also in its first part.	† Died from "exhaustion" 19 days after the first operation—5 days after the second operation. Patient had severe secondary haemorrhages. Infected wound.	The case is so briefly and indefinitely reported that one is not quite sure that the artery was ligated in its first part. The author states that he "threw a thread around" this portion. Fine silk used for the ligature of the subclavian was probably responsible for the first haemorrhage if the operator is correct in assuming that there was no infection.
IV	Bardenheuer, B. Die Verletzungen d. oberen Extremitäten. Deutsche Chirurgie, Stuttg., 1886, Lief. 63a, Th. I, p. 445.	M. aet. 47.	A very large, hard, quite freely movable tumor, believed to be carcinoma, in the left supraclavicular fossa. It extended to the midline and pushed the larynx far to the right; externally it touched the outer edge of the sternomastoid; below it disappeared behind the clavicle and manubrium. The carotid and subclavian arteries and the internal jugular and subclavian veins entered the tumor.	Radial pulse unaffected. No oedema of arm, nor pressure upon nerves.	Date not given. Resection of inner half of clavicle, 5 cm. of first rib, and a piece of manubrium 5 x 4 cm. Subclavian vein doubly ligated and divided peripheral to tumor. Ligation also of internal jugular and innominate veins, of the carotid and subclavian (central and peripheral) arteries. The proximal ligature of the subclavian was placed 1½ cm. from the aortic arch. Excision of the tumor. The vagus nerve and the thoracic duct in the neck had to be divided in the neck.	† Died suddenly 18 hours after operation.	No pathological report.

LIGATION OF THE FIRST PORTION OF THE LEFT SUBCLAVIAN ARTERY.—CONTINUED

No.	Operator and publication	Sex and age	Description of tumor	Symptoms	Operation	Result	Comments
V	Halsted, W. S. Ligation of the first portion of the left subclavian artery and excision of a subclavioaxillary aneurism. Johns Hopkins Hosp. Bull., Balto., 1892, iii, p. 93.	M. aet. 52.	Spherical tumor above, behind, and below the clavicle, overlapping in front and almost concealing its middle third. The tumor's circumference at base measured 42 cm. Internally it extended to within 5 cm. of the left sternoclavicular joint; externally, to within 4 cm. of the coracoid process. Pulsation in the tumor was feeble.	No pulse palpable at any point distal to the tumor. Left arm not swollen nor cooler than the right; shortness of breath; hoarseness; slight numbness in forearm and hand. Entire absence of pain.	May 10, 1892. Excision of inner third of clavicle; double ligation and division of subclavian artery in its first portion; excision of aneurism, the greater part of the remaining clavicle, a piece of the deltoid muscle and about 6 cm. of the subclavioaxillary vein and the first part of the axillary artery in one piece. A large dead space which could not be completely covered by skin was sealed with gutta percha tissue.	Cure	The blood clot filling the dead space, only partly covered by skin, organized throughout. There was no swelling nor coldness of the extremity after the operation.
VI	Schumpert, T. E. Ligature of the left subclavian in its first part for aneurism of third. (Recovery.) Med. Rec., N. Y., 1898, liv, p. 338.	M. aet. 56.	"An aneurism about the size of an orange involving the third part of the left subclavian artery."	Oedema of shoulder and arm. Constant pain. No mention made of examination for loss of nerve-function. Radial pulse present—whether affected is not stated.	March 7 (year not given). Double ligation with No. 8 braided silk of the first portion of subclavian artery; the ligatures placed 1/16 inch apart. Clavicle not resected or divided. Wound completely closed. Collodion dressing.	Recovery. No statement in regard to the ultimate effect on the aneurism.	Patient observed for only 9 weeks. The oedema of the arm, shoulder and hand had entirely vanished; the radial pulse had not reappeared. Interesting to note that when the radial pulse is present and the subclavian vein obstructed the oedema may be greater than in the cases of obliterated radial pulse (cf. preceding case).
VII	Kammerer, F. Ligature of the first portion of the left subclavian artery for aneurism; death after 4 weeks. Med. Rec., N. Y., 1889, lvi, p. 924.	M. aet. 47.	Pulsating tumor as large as a man's fist in left supraclavicular fossa external to and under the sternomastoid muscle.	Radial pulse "scarcely retarded." Numbness of third and fourth fingers. No preoperative statement in regard to swelling of the arm.	Oct. 18, 1899. Resection of 2 inches of left clavicle, 1½ inches of right clavicle, 2 in. of 1st left rib and a part of the manubrium. Ligation of the left subclavian artery 1 inch from its origin.	† Died 1 month after operation from secondary haemorrhages. No statement in regard to effect of the operation upon the aneurism.	Death was probably due to unequal absorption of the several strands of the catgut ligature—to a cutting through of the final strand which may or may not have totally occluded the artery. There was no swelling of the arm in consequence of the ligation—whether swollen before operation is not stated.
VIII	Jüngst. Ein geheilter Fall von Unterbindung d. Arteria subclavia sin. am Aortenbogen. Beitr. z. klin. Chir., Tüb., 1902, xxxiv, p. 307. Philipp, J. A. Unterbindung d. Arteria subclavia in ihrem ersten Abschnitt nach Schussverletzung. Inaug. Diss., Leipz., 1900, p. 17.	F. aet. 35.	"The whole supraclavicular region is filled with a hard-soft swelling." Neither bruit nor pulsation perceptible. Pea-sized bullet wound about 2 cm. from sternal end of left clavicle. No exit wound.	Radial and ulnar pulses unaffected; upper arm quite swollen. Pains in shoulder radiating to arm. "Sensation of skin to touch, temperature and pain much diminished—in places absent." "Complete motor paralysis."	July 24, 1899. Resection of sternal third of clavicle and of the whole manubrium. Ligation with silk of subclavian 1½ to 2 cm. from its origin, also on each side of slit, made by a bullet, "precisely at the point where the artery emerges from between the scaleni." The entire large wound was stuffed with gauze. Severe haemorrhages occurred during the operation.	Recovery and cure. Convalescence stormy. Thoracic duct wounded. Maceration of skin of neck and back. Marked thirst while flow of chyle continued. Complete paralysis of left recurrent nerve. Mobility of upper arm regained quickly; of forearm and hand slowly.	Wound cavity stuffed with gauze down to aortic arch.

LIGATION OF THE FIRST PORTION OF THE LEFT SUBCLAVIAN ARTERY.—CONTINUED

No.	Operator and publication	Sex and age	Description of tumor	Symptoms	Operation	Result	Comments
IX	Stonham, C. A case of aneurism of the second and third parts of the left subclavian artery; ligature of the first part, etc. Lancet, Lond., 1902, ii, p. 291.	M. aet. 43.	Swelling size of a duck's egg in left supraclavicular fossa extending inwards to middle of sternal part of sternomastoid. Expansile pulsation and bruit.	Radial pulse unaffected. No mention is made of pain or swelling or impairment of function.	Op. I. Apr. 26, 1899. Resection of 1 inch of sternal end of clavicle. Ligation with floss silk of the first portion of a presumably rather high subclavian artery. The ligature "was situated behind the sterno-clavicular joint about ½ in. from the aneurismal sac. Gauze drain." Pulse in the sac and radial artery "arrested." Op. II. June 28, 1899. Ligation of the vertebral, inferior thyroid and third part of axillary arteries; wound packed with gauze.	Cure	Pulse in radial distinct in 24 hours, and in sac in 4 days post op. I. Gradual increase in size of aneurism. Hand became swollen; pain; impairment of finger motions. The ligation of the vertebral and inferior thyroid arteries at the second operation did not arrest the pulsation of the sac. The axillary artery was therefore ligated "just above" the subscapular branch and thereupon pulsation in the sac and brachial and radial arteries ceased. This is the only aneurism of the spontaneous variety on our list not cured by the ligation of the subclavian. May not this aneurism have been due primarily to a cervical rib (*vid.* discussion in text)?
	Banks, Sir Wm. [Attempted ligation of the first portion of the left subclavian artery.] Lancet, Lond., 1903, i, p. 103.	"Young healthy man."	"The aneurism, due to a railway crush, had spread into neck and was as much subclavian as axillary."	.....	Date not given. "Made a strenuous attempt to ligature the first part of the left subclavian artery in the thorax; the pleura was a good deal injured and the patient died from pleurisy." The attempt was unsuccessful.	Pleurisy.	
X	Delbet, P. Anévrisme de la sous-clavière gauche. Bull. et mém. soc. de chir., Paris, 1910, xxxvi, p. 1114.	M. age not given.	Traumatic aneurism in supraclavicular fossa. Size and precise situation of tumor not specified.	Terrible neuralgic pains relieved by "resection of the last two cervical pairs." Radial pulse absent. No mention of swelling.	Date not given. Exposure of sac; resection of inner third of clavicle and a part of the manubrium; ligation of subclavian within the thorax and also distal to the sac; "formidable haemorrhage" on opening sac before the distal subclavian was tied. Permanent tamponage of sac to control bleeding.	Recovery. Paralysis persists. Nutrition of limb unimpaired.	The operator probably merely *freed* the last two cervical pairs, it being hardly conceivable that he would have resected them. It is interesting to note that the freeing of the nerves entirely relieved the pains. It would seem that the sac should have been excised rather than tamponed.
XI	Pierre Duval, Reported by Schwartz, Ed. Enorme anévrisme diffus du cou et de la région sous-claviculaire. Paralysie du membre sup. gauche. Compression du récurrent gauche. Bull. et mém. soc. de chir., Par., 1910, xxxvi, pp. 874, 1138.	M. aet. 31.	Enormous, tense, fluctuant tumor reaching from clavicle to jaw and displacing larynx and trachea. There was neither pulsation nor bruit. Diagnosis: traumatic aneurism.	Temporal pulse hardly perceptible; radial pulse enfeebled; complete paralysis of limb (oedema not mentioned); raucous, inaudible voice; dysphagia; ptosis, myosis and enophthalmus.	Aug. 8, 1910. Resection of inner half of the clavicle, of left half of manubrium and of the first costal cartilage; arch of aorta exposed; precautionary loops within thorax about carotid and subclavian; incision of aneurism; subclavian found to be cut across at the internal border of 1st rib; ligature of the two ends. Time, 50 minutes.	Died † suddenly a few hours post op.	Duval believed that death was due to embolus originating from clot at site of temporary ligation of carotid. I am unable to share this belief. Duval very briefly describes the operation in a letter to Schwartz. Whether the precautionary loop about subclavian was tied is not stated. In any event the proximal ligature must have been on the first portion.

LIGATION OF THE FIRST PORTION OF THE LEFT SUBCLAVIAN ARTERY.—CONTINUED

No.	Operator and publication	Sex and age	Description of tumor	Symptoms	Operation	Result	Comments
XII	Browne, Capt. C. G. A case of diffuse traumatic aneurism and ligature of the first part of the subclavian. Brit. Med. Jour., Lond., 1911, ii, p. 1534.	M. age not given.	Bayonet wound of left axilla. "Collection of blood in the subclavicular region and inner part of the axilla."	Left radial pulse equal to right. Arm swollen.	Aug. 28, 1911. Subclavian artery "descending vertically along the inner border of scalenus anticus" was ligated. Cervical wound drained. Axilla opened, clots removed, drainage tube inserted.	Cure	The better the pulse and the greater the obstruction to the veins the greater, naturally, should be the swelling of the limb. The high course of the artery suggests cervical rib or its Anlage. As there was no pulsation in the axillary haematoma and no haemorrhage after eventration of the clots it is improbable that the axillary artery had been pierced by the bayonet. Possibly only a vein was injured. Ligation of the subclavian was perhaps not indicated.
XIII	Neff, J. M. Ligation of the first portion of the left subclavian artery. Ann. of Surg., Phila., 1911, liv, p. 503.	M. aet. 23.	The operation was for haemorrhage from a hole in the subclavian artery discovered in the course of a dissection for the removal of cervical glands.	.....	Op. I. Feb. 12, 1910. Two clamps placed on either side of a "hole" in the subclavian artery discovered at end of operation for excision of cervical glands. Drainage tube. Op. II. March 4, 1910. Clavicle divided about 1¼ inches from sternum and ends retracted downwards. Ligation of subclavian ¾ inch above aortic origin; permanent clamp placed on the artery ¼ inch distal to the ligature; double-silk ligature distal to defect in subclavian, and proximal to this another permanent haemostat; ligation of thyroid axis, vertebral and internal mammary arteries.	Recovery. Marked atrophy and weakness of limb; sensation abolished for 4 months post op. Ultimate restoration of function.	How remarkable that the operator should have left the clamps hanging in the wound when he might have ligated the subclavian on either side of the "hole" in the artery! (*Vid.* text for further comments.) The thyroid axis(vertebral and internal mammary arteries were ligated because the first portion of the subclavian was too soft to admit of ligation. The softness may well have been due in part to the infection and the permanent haemostat.
XIV	Rubritius, H. Die chir. Behandlung d. Aneurysmen d. Arteria subclavia. Beitr. z. klin. Chir., Tüb., 1911, lxxvi, p. 144.	M. aet. 21.	Stab wound. "In the left supraclavicular region there is a pulsating tumor the size of a fist at the summit of which, close to the outer edge of the sternomastoid, there is a scar about 1 cm. long." Systolic bruit, audible also over axillary artery. At operation it developed that the aneurism was of the second part of the subclavian.	Left pulse slightly weaker than right. Left arm somewhat cyanotic.	Op. I. Oct. 5, 1909. Clavicle sawed through at middle, and sternal half removed; resection of the left half of manubrium and 4 cm. of first rib. Pleura wounded. Rubber tube carried around first portion of the artery and twisted at intervals during next 24 hours in order to make the occlusion gradual. Drainage. Op. II. Oct. 27. Rubber tube replaced by 2 silk ligatures. Some days later drainage of left empyema. Op. III. Apr. 25, 1910. Resection of seventh, eighth, ninth and tenth ribs (thoracoplasty) for empyema.	Recovery. Nov. 16, 1909: "At site of aneurismal tumor one feels a firm mass." No subsequent note in regard to tumor.	I have found no evidence to sustain the fear that gangrene may follow the ligation of any portion of either subclavian artery. There was therefore no indication for the attempt to occlude the artery gradually, and particularly none by a method which superimposed the danger from infection of the wound. The gangrene which followed the difficult and brilliantly executed operation of Matas for arterio-venous fistula of the right subclavian vessels seems quite unquestionably to have been due to the fact that a fistula had existed for some days prior to the operation. The ligation of the branches of the first and second portions of the subclavian artery may have been a contributing factor. The existence of a fistula may retard the development of the anastomotic circulation.

No.	Operator and publication	Sex and age	Description of tumor	Symptoms	Operation	Result	Comments
	Sherrill, J. G. Report of a case of aneurism, with a new method of ligature of the left subclavian. Trans. Southern Surg. & Gyn. Assn., 1911, xxiii, p. 190.	M. aet. 30.	The operation was undertaken for "a pulsating tumor about the size of a small melon situated at the upper part of the thorax, extending from near the median line and just above the level of the clavicle downward and outward almost to the margin of the pectoralis major muscle." No bruit.	Pain and tenderness in the left shoulder; tenderness above spine of scapula and in the left axilla. Left radial pulse almost imperceptible.	Jan. 27, 1910. Resection in the back of about 3 inches of the second, third and fourth ribs. Left subclavian artery ligated extrapleurally near its origin with No. 3 catgut. As pulsation in the aneurism was unaffected by this ligature and it was discovered that a diagnostic error had been made the ligature was removed. "Further search revealed below the origin of the subclavian a rounded mass, seemingly not larger than a small orange, which was pulsating." Wound closed.	† "Patient died Feb. 7, 1910, on raising up suddenly in bed." "The postmortem demonstrated an aneurism of the arch of the aorta in its lower portion, which had ruptured into the esophagus."	As Dr. Sherrill removed the ligature on discovering that the aneurism was not of the subclavian artery, his case, well worth recording, is entitled only to be classed with the cases of temporary ligation. The novel method of operative approach (from the back) is notable. It was adopted because the location of the supposed aneurism seemed to block the usual route.
XV	Newbolt, G. P. A case of aneurism of the second and third parts of the left subclavian artery in a woman. Brit. Med. Jour., Lond., 1912, ii, p. 867.	F. aet. 50.	Pulsating swelling involving the second and third parts of the subclavian artery and extending into the axilla.	.....	March 14, 1912. Resection of sternal end of clavicle. Subclavian tied in its first portion by two silk ligatures placed ½ inch apart. Endeavor made not to damage the arterial wall in tying. One end of each ligature was left uncut and the two threads were then tied together. Pulsation in aneurism stopped. Wound closed without drain.	Recovery. March 15: No pulse in radial; fingers warm. Apr. 15: "Swelling in neck felt like a soft cyst, and the axillary sac was smaller and harder." June 8, 1912: "The aneurism had practically disappeared, but her left hand was decidedly colder than the right." There is no further note.	Have we reason to believe that two ligatures ½ inch apart are safer than one? Possibly the second (distal) ligature might safeguard the first by taking off the back-pressure but this pressure would probably be slight unless there were a branch distal to and near the proximal ligature.
XVI	Wieting, Prof. Die Unterbindung d. Arteria subclavia sin. in ihrem I. Abschnitt. Zentralb. f. Chir., Leipz., 1912, xxxix, p. 1156.	M. aet. 35.	Dec. 24, 1911. Shot in back at upper angle of left scapula. "Above and on the clavicle, beginning about 3 cm. from left sternoclavicular articulation and reaching to the shoulder-joint is a strongly pulsating tumor about half the size of a goose egg. Ecchymosis extends over the whole left side of the neck to the nape, and downwards on the thorax to the pelvis. The pulsating swelling extends far into the depths towards the back and can be felt to within a few cm. of the entrance wound."	Radial pulse absent; arm not swollen. Complete paralysis of the limb including shoulder; sensation intact; shooting pains. Left side of thorax filled with blood. Bloody sputum.	Jan. 4, 1912. Blood depots established in both legs and left arm. Resection of sternal end of clavicle and a piece of sternum. Double ligation and division of internal jugular and vertebral veins. Thick celluloid thread provisionally passed around the first portion of the subclavian artery. Temporary occlusion with rubber-covered Höpfner-Stich clamp. Aneurism opened wide, clots removed. Quite abundant haemorrhage, hence exploration of the great cavity difficult. The precautionary ligature was tied, the sac stuffed firmly with gauze, and the wound closed.	Recovery. Radial pulse still absent. Two months post op., "Mobility slowly returning; fingers and elbow can be moved. Further news of patient not obtainable.	To pack a wound to arrest haemorrhage, particularly one in which a large artery has been tied, is inadvisable; it is also a confession of defeat.
XVII	Gaudiani, V. Ligation of the first part of the left subclavian for aneurism. Med. Rec., N. Y., 1915, lxxxvii, p. 331.	M. aet. 46.	"Pulsating tumor the size of an egg" behind the sternal notch and under the left sternomastoid. Murmur over tumor; audible also over axillary artery.	Anaesthesia of inner side of forearm and dilation of the left pupil. Radial pulse present.	May, 1913. Intratracheal insufflation. Ligation and division of internal jugular. Ligation of the first portion of subclavian artery with a silk ligature.	Recovery.	

LIGATION OF THE FIRST PORTION OF THE LEFT SUBCLAVIAN ARTERY.—CONTINUED

No.	Operator and publication	Sex and age	Description of tumor	Symptoms	Operation	Result	Comments
XVIII	Hamann, C. A. Ligation of the first part of the left subclavian artery. Ann. of Surg., Phila., 1918, lxviii, p. 219.	M. aet. 50.	Aneurism about 1 inch in diameter of the second and third portions of the left subclavian artery; this tumor had been noticed for about one year.	Some pain; "no marked evidences of pressure on the vein or nerves."	May 10, 1917. Scalenus anticus muscle divided. "A double ligature of braided silk was passed around the vessel and firmly tied. Pulsation in the sac ceased and did not return."	Recovery. Four or 5 months post operation the sac had contracted into a small firm mass; the patient was quite well.	The subclavian artery seems to have coursed high in the neck, and the ligation of its first portion to have been simplified in consequence. We have in mind the possibility of cervical rib or its Anlage.
XIX	White, J. S. Traumatic aneurism of the left subclavian artery; successful ligation at the junction of the first and second portions. Brit. Med. Jour., Lond., 1918, ii, p. 131.	M. aet. 35.	Gunshot wound Aug. 16, 1917. Pulsating swelling appeared Nov. 16. Small saccular aneurism of second portion of subclavian.	No mention of symptoms from pressure upon nerves or vessels. As the neck of the sac was between the scaleni the cords of the brachial plexus would presumably have been compressed.	Op. I. Dec. 8, 1917. Col. A. M. Connell. Proximal ligature not attempted owing to dense matting of tissues. Strand of stout catgut tied around base of aneurism where it sprang from the upper convex margin of the artery. Op. II. Jan. 2, 1918. J. S. White. Clavicle divided, inner half pivoted to right; scalenus anticus severed. Subclavian ligated at junction of first and second portions with double strand of No. 1 Van Horn's catgut. Ends of clavicle sutured with catgut. Rubber drainage tube for 72 hours.	Recovery.	The improvement following ligation of neck of sac was of very brief duration. The second operation should not, perhaps, be classed as a frank ligation of the first portion. As no mention is made of the superior intercostal I assume that the ligation was external to this branch.
XX	Ballance, Sir C. A case of ligation of the first part of the left subclavian artery. Jour. Roy. Army Med. Corps, Lond., 1918, xxxi, p. 417.	M. aet. 31.	July, 1916. Wound by shrapnel bullet. Jan., 1918. Small pulsating tumor in supraclavicular fossa; dullness for 2 inches below clavicle. *Vid.* original paper for radiograms and sketches. Diagnosis: aneurism of second and third portions.	Numbness, shooting pains, weakness; faint radial pulse; arm warm; no mention of swelling.	Feb. 4, 1918. Resection of inner third of clavicle. Discovery made that the artery had probably been wounded at junction of first and second portions. Ligation of subclavian artery behind the vertebral vein, with three medium-sized strands of kangaroo tendon; stay-knot. Pulsation in aneurism ceased. No mention made of drainage. Healing throughout *per primam*.	Recovery. Progressive improvement in function. Aneurism solidifying. "The clavicle became fixed to the first rib."	This is the only case, Gaudiani's excepted, in which the point of origin of the aneurism was so far inwards as the junction of the first and second portions.
XXI	Halsted, W. S. Intrathoracic ligation of the left common carotid artery and of the first portion of the left subclavian artery for huge subclavian aneurism. Johns Hopkins Hosp. Surg. Hist. No. 46179.	M. aet. 29.	Patient was shot in neck about 4 years before admission; 3 years later first noticed a swelling above the clavicle. A huge aneurism of the left neck extending from clavicle to ear; the pulsating tumefaction extends on to the chest and posteriorly spreads out to a point below the spine of the scapula; the clavicle is eroded completely through at about its middle; the head is deflected and rotated to the right; the larynx and trachea displaced. *Vid.* photographs. The soft parts all about the aneurism are infiltrated.	Paralysis, almost total, of motion and sensation. Very severe pain from shoulder to fingers. Radial pulse absent; arm swollen. The whole body is jarred with each pulsation.	Op. I. Apr. 26, 1918. Ligation of left common carotid and left subclavian arteries near their aortic origins. Wound sealed. Op. II. Apr. 10, 1920. Excision of the sac which had become reduced to about the size of a small fist, but was beginning to enlarge. Wound sealed.	Recovery. Apr. 20, 1920: Paralysis slowly but steadily diminishing; sensation improving. Patient can flex and extend elbow, abduct shoulder, and move, slightly, the flexed fingers.	Primary healing of the wounds. This is probably the largest subclavian aneurism ever operated upon.

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A STRIKING ELEVATION OF THE TEMPERATURE OF THE HAND AND FOREARM FOLLOWING THE EXCISION OF A SUBCLAVIAN ANEURISM AND LIGATIONS OF THE LEFT SUBCLAVIAN AND AXILLARY ARTERIES[1]

In a series of signally interesting papers Prof. René Leriche calls attention to the value of what he terms periarterial sympathectomy in the treatment of various neuralgias, local ischemias, reflex contractures of the Babinski-Froment type, and other affections. Fostered in the traditions of the schools of Magendie, Claude Bernard, and Brown Séquard, it was in the happy order of things that it should fall to the lot of a surgeon of Lyon to turn to therapeutic account a discovery of the greatest of the founders of experimental medicine. A devoted disciple of Jaboulay, Leriche credits this talented surgeon, his "master," with the suggestion which led to the novel and important researches made by him during the years of the war.

My interest in Leriche's work has been reawakened by an observation made only a few weeks ago in the Surgical Clinic of The Johns Hopkins University. In 1918 I ligated the left subclavian and carotid arteries near their origin from the aorta for the cure of a huge subclavian aneurism (Plate XLIII, 1 and 2). For a year the aneurism decreased steadily in size (Plate XLIV, 1 and 2, and Plate XLV, 1 and 2). Then for a year we lost track of the patient. About two months ago we succeeded in tracing him, and persuaded him to let us excise the aneurism, which in the period of nonobservation had developed a faint pulsation and become slightly larger (Plate XLVI, 1). About four hours after this operation, at which the aneurism was excised and the subclavian and axillary arteries ligated, it was noticed that the left hand and forearm, which for two years had been strikingly cold, had become abnormally warm—appreciably warmer than the corresponding limb. Unfortunately, our surface thermometer had been broken and we were unable to obtain another. About five weeks after the operation the hand and forearm became cold again—at first in small areas—remaining cold for only a day or two.

Today (June 28th), the 69th since the operation, the back of the left hand is quite cold, whereas the left palm is about as warm as the right. The temperature of the hand and forearm has varied from day to day and from hour to hour; certain small, quite well-defined areas have remained uni-

[1] Johns Hopkins Hosp. Bull., Balt., 1920, xxxi, 219-224. (Reprinted.)

formly cool; otherwise, the hand and forearm have maintained their normal warmth.

Sur. No. 46179. Alexander Miller. Negro, aet. 29. Admitted to The Johns Hopkins Hospital April 22, 1918; discharged August 12, 1918.

The patient states that he has always been perfectly well. In April, 1917, he noticed a swelling about the size of an egg above the left clavicle. Almost simultaneously with the recognition of the swelling, pain and numbness in the upper extremity were observed. The growth of the tumor was gradual until about March, 1918; since then it has been very rapid. For the past two weeks the limb has been totally paralyzed. The patient recalls that until Christmas, 1917, he could still raise his arm a little.

About four years before admission the patient was shot just above the left clavicle. The wound healed promptly. The bullet was not removed and has given him no indication of its presence.

Examination.—The patient is evidently suffering severe pain, and constantly supports his left wrist with his right hand. The pain, he says, is most intense from the elbow-joint to the hand and in the left shoulder.

A huge aneurism occupies the left neck from the clavicle to the ear (Plate XLIII, 1 and 2). The head is deflected and rotated to the right. The vertex of the pulsating mass is about on a plumb-line dropped to the junction of the middle and inner thirds of the clavicle. The swelling and pulsation extend on to the chest, and the whole body is jarred with each heartbeat. Posteriorly the diffuse pulsating tumefaction spreads out to a point below the spine of the scapula. The aneurism extends upward in dome-shape; a hand can be inserted between it and the face down to the angle of the lower jaw. The whole shoulder girdle appears to be raised away from the chest wall, the acromioclavicular articulation being apparently disrupted. The skin over the tumor is very tense and glistening. From the clavicle to about the level of the nipple the brawny tissues are probably infiltrated with blood as well as inflammatory products. The trachea is displaced to the right. A systolic bruit, most distinct above the inner third of the clavicle, can be heard over the greater part of the pulsating mass. No thrill can be felt. The left radial pulse is absent. There is slight ptosis of the left eyelid, but the pupils respond equally. Only the inner third and the acromial tip of the clavicle can be defined with the fingers. The remainder of the bone is buried in the tumefaction. A bullet is palpable just beneath the skin to the left and below the spine of the seventh cervical vertebra. The left arm is paralyzed. The extent of the loss of motion and sensation and the degree of restoration of function will be outlined in a subsequent paper.

Fluoroscopic Examination.—The shadow of the aneurism extends to the lower border of the clavicle but not to the first rib. The heart seems not to be enlarged. The right subclavian and carotid arteries, distinctly seen, are normal in size.

Skiagraphic Report.—Large mass in left neck. Clavicle deeply eroded, perhaps fragmented. Bullet in upper dorsal region.

Operation, April 26, 1918.—(Dr. Halsted.) *Ligation of the left common carotid and the left subclavian arteries near their origin from the aorta.*

Ether. Wide protection of the operative field with celloidin-silk.[2] Transverse bow-incision just below the cervicothoracic junction, supplemented by a vertical one along the left border of the sternum (bow and plummet incision). Free exposure of manubrium and left sternoclavicular joint. The incised tissues were oedematous, particularly so below the clavicle. The superficial vessels were abnormally large. Careful haemostasis by the fine silk transfixion method. The left two-thirds of the manubrium and the left sternoclavicular joint were resected with the giant rongeur forceps of Esmarch, care being taken to avoid disturbing the fragments of the eroded clavicle. The thymus gland and the left innominate vein were drawn upward and to the right with a retractor.

The trachea in the thorax as well as in the neck was displaced to the right by the pressure of the aneurism. The left carotid, deeply situated and occupying the midline in the chest, was gently occluded with a tape ligature. This artery was thought at first to be the left subclavian inasmuch as, according to the erroneous testimony of an assistant, its occlusion did not affect the pulse in the left temporal artery, and lessened the force of the pulsation in the aneurism. To obtain access to the left subclavian artery the cartilage of the left first rib and the adjoining margin of the sternum were cut away. The arch, the aortic isthmus and descending aorta, and the left auricle of the heart were palpated with the finger of the operator before the left subclavian, lying close to the vertebral column, was identified. With the aid of four long, narrow dissectors, two of which were manipulated by the operator and two by Dr. Mont Reid, the vessel was clearly exposed at its origin from the aorta and for several centimeters distal to this point. As it was evident that none of the various aneurism needles was suitable for the passage of a ligature at this depth, a long, narrow, blunt dissector, slightly curved and pierced at its tip, was armed with fine silk and passed under the artery. By means of this thread and then another, linen tapes were drawn under the subclavian; both of these were tied, the second distal and close to the first, with force only sufficient to close completely the artery's lumen. The aneurism became very tense and hard immediately after the ligation, but was pulseless.

The patient's condition, bad on admission and particularly so just before operation, caused us some anxiety. Traction within the thorax on the branches of the aortic arch or on the pulmonary artery affects unfavorably and eventually disastrously the action of the heart. The pulse, about 120 at the beginning, was 140+ and quite weak at the termination of the operation. The wound was completely and accurately closed with interrupted sutures of fine silk. A large dead space in the mediastinum was, naturally, unavoidable.

Healing *per primam.*

November 9, 1918.—The patient has been examined frequently since his discharge from the hospital. There has been no pulsation in the aneurism since the operation. The mass has steadily but slowly decreased in size. The patient can make slight movements with the left fingers, otherwise

[2] W. S. Halsted. Clinical and experimental contributions to the surgery of the Thorax. Trans. Amer. Surg. Assn., 1909, xxvii, p. 111.

there has been no appreciable return of power or sensation in the paralyzed arm.

The patient was observed frequently throughout the year following the operation. Slowly but steadily the pulseless tumor, during this period, diminished in size. Then for a year the patient, living out of town, was lost sight of. Exactly two years after the first operation he returned, at our solicitation, to the hospital. Now for the first time since the operation a very faint pulsation was discernible. The tumor (Plate XLVI, 1) measured in its transverse (frontal) diameter precisely the same as when last seen a year before; the anteroposterior measurement (sagittal), however, gave an increase of about 4 cm. I decided that the aneurism should be excised, and on the 20th of April, 1920, performed the operation as follows:

The skin over the tumor and a wide area about it were protected with Chinese silk dipped in celloidin. The incision, made through the tightly adherent silk, ran with the clavicle in its central part, curving up into the neck at its inner end, and down along the cephalic vein at its outer. Superimposed on and not attached to the greatly broadened and thickened clavicle was a sharply convex bow of bone about 9 cm. long and 6 mm. thick. This bow, recognizable in the photograph (Plate XLV, 1), was cut away and the clavicle bitten through with a heavy rongeur forceps at two points as close to the aneurism as possible. The cephalic vein was divided, and the axillary artery—pulseless, reduced in size, but not empty—was ligated about at the junction of its first and second portions, through a split made in the pectoralis minor muscle; the third portion of the subclavian artery was ligated above the clavicle; the aneurismal sac, and the resected rib were excised in one piece. The aneurism was matted almost everywhere to the surrounding parts by dense connective tissue, and hence had to be carved out rather than enucleated. The identification and freeing of the roots of the brachial plexus, which were in places embedded in the wall of the sac, consumed much time. The operation was conducted in a bloodless manner until nothing remained to be done except to divide the narrow neck of the sac. The tissues of this neck proved to be thin and friable, and the patient lost a few cubic centimeters of blood through the slit in the artery—the mouth of the false sac—which was readily closed with three stitches of fine silk. The wound was closed without drainage. I am greatly indebted to Dr. Heuer and Dr. Reid for their skilful and highly competent assistance which enabled me without concern to conduct the operation to a satisfactory conclusion.

At the first dressing, made on the 10th day after operation, it was noted that a little fluid had accumulated in the outer part of the wound. This was evacuated by puncture with a wooden toothpick wrapped with a few fibres of cotton dipped in pure carbolic acid. Closure of the puncture was prevented by the reapplication of the acid in the same manner on two alternate days. The introduction of a drain of any kind we scrupulously avoid. The word "drainage-tube" is in disfavor in our clinic. Should a wound become infected, tubes would be properly introduced for the purpose of disinfection, but not for drainage.

Noteworthy is the fact that the patient's hand and forearm, which prior to and ever since the first operation had been markedly cold, became strikingly warm about 4 hours after the second operation and have remained warm, except in certain areas, to the present time (June 28th). It is improbable that the ligation of the cephalic vein was in any part responsible for this indubitable improvement in the circulation. The elevation of the temperature of the hand and forearm must, I believe, be attributable to vasodilatation incident to the ligations of the subclavian and axillary arteries—to the crushing of their nerves. This question will be discussed in the course of the consideration of the treatment of subclavian aneurisms in a paper about to appear in The Johns Hopkins Hospital Reports.

I have found pleasure in translating one of the papers of Monsieur Leriche, believing that his work on periarterial sympathectomy will at this moment particularly interest surgeons who may have the opportunities and the inclination to verify his observations. While disclaiming unqualified acceptance of some of his explanations and deductions which are at variance with the teachings of physiologists, we must recognize that Leriche's contributions are of unusual interest and value; they will stimulate investigation.

PERIARTERIAL SYMPATHECTOMY AND ITS RESULTS

René Leriche

In January, 1916, and in April of the same year,[3] I made known the first results which the denudation and excision of the sympathetic plexuses around the arteries in causalgia and in certain trophic troubles had given me. Since then this operation has been tried in various ways. Le Fort, Cotte, Sencert, Lavenant, de Massary and Veau, Prat, have reported experiences with it. I personally have performed it 37 times.[4] The moment seems to have come to indicate briefly the essential facts which the procedure has taught me. Elaborating the idea of Jaboulay, we must indeed develop a true and general operative method susceptible of very varied applications.

I think at the outset that it ought to be designated by an exact name: it is a peripheral sympathectomy which, according to the level where it is practised, ought to be called axillary sympathectomy, brachial, iliac, femoral, etc.

I. Technique.—In order to achieve it, it is necessary to uncover the artery by the classic procedure, open with the bistoury the cellular sheath, separate the artery for 8 to 10 cm., get hold of the inner sheath directly on the vessel wall, incise it, pull one of the lips thus made with a forceps, free it either with the bistoury or with the grooved probe, completely stripping

[3] R. Leriche: De la causalgie envisagée comme une névrite du sympathetique et de son traitement par la dénudation et l'excision des plexus nerveaux péri-artériels. Société de Neurologie, 6 Janvier 1916; La Presse médicale, 20 Avril 1916.

[4] More exactly, I have done 30 sympathectomies by denudation and 7 times complete sympathectomy by resection of a segment of obliterated artery.

the artery of all the cellular tissue that adheres to it. More or less easily according to the cases, one is able thus to strip the artery, to decorticate a fold; thin, to be sure, but often thicker than one might expect. At a certain moment one has the impression that one is going to tear the wall of the artery; but if one proceeds gently and carefully, guided by the point of the bistoury or probe, the freeing process can be carried on without risk of injuring the vessel. Only twice have I had the annoyance of making a small tear in the artery; the accident was without serious results. In case of necessity one would frankly resect the segment of the tear and tie the two ends, accomplishing thus by the same act a complete sympathectomy. Sometimes the forceps removes only rather short cellular fragments, at other times one removes quite definite laminae, and the movement of freeing recalls, on a small scale, the subserous decortication of an inflamed appendix, but one never succeeds in removing a continuous layer; it is necessary to repeat the attempt several times and with perseverance to catch the sheath again, to remove thin meshes, and not to stop until one has really the feeling of having removed everything. Moreover, one can verify what has been done by wetting the wound with a tampon soaked with very warm serum: the artery takes on then a whitish appearance, looks as though made of felt, and one sees very clearly whether there remains still some cellular débris more or less detached.

In the course of the cellular decortication it is necessary to be careful to expose the collateral branches and guard against tearing them. This happens sometimes; by using then a forceps and a ligature of 00 catgut one repairs this accident without injury to the artery. In addition to the tears, which cause a spurt of pure blood, there may be oozing from the tearing of the vasa vasorum.

II. The Physiological Reaction.—The operation thus done is a physiological operation; I mean to say by this that it is inevitably followed by a characteristic physiological reaction, which may be regarded as the *test of the operation;* as there are characteristic signs of the section of the trunk of the sympathetic in the neck, so there are characteristic signs of the section of the periarterial sympathetic nerves. If these are wanting, the operation has been attempted but not accomplished.

The results of our studies of these signs Heitz and I have reported to the Société de Biologie;[5] they are as follows:

Primary Sign.—When one touches the sympathetic sheath, the artery contracts; it is reduced progressively in size to the point where it is not more than a third or even a fourth the normal size throughout the whole extent of the denuded segment. The segments on both sides maintain their normal size provided the operation has not injured them. The phenomenon is more or less rapid according to the case; certain individuals appear to have more irritable sympathetic nerves than others; their arteries diminish in size at the first touch; with some the contraction is sluggish. One cannot yet give the real reason for these variations. Furthermore, the contraction is more marked in the brachial than in the axillary and the subclavian; it is slower

[5] Leriche and Heitz: Des effets physiologiques de la sympathectomie périphérique réaction thermique et hypertension locales). C. R. de la Soc. de Biol., 20 Janvier, 1917.

in the femoral than in the brachial, and less intense in the common iliac than in the femoral. In a word, the contraction is stronger in the arteries of small size than in the large trunks.

This arterial contraction habitually causes the pulse to disappear, but it does not altogether interrupt the circulation.

Secondary Signs.—In the following hours the pulse is imperceptible or very feeble and the limb is colder than the other. Then little by little, at the end of three hours, six hours, and most often twelve or fifteen hours, there appears the *characteristic physiological reaction,* the establishing of which ought to be exacted as proof that suppression of the sympathetic nerves has been properly done.

This reaction is characterized by an elevation of the local temperature reaching to 2° and even 3° [centigrade], by the elevation of the arterial pressure, and by the augmentation in the amplitude of the oscillations of Pachon. M. Heitz, who with his very special competence has established these facts many times on my patients, has found that the increase in pressure could be as much as 4 cm. of mercury in comparison with the healthy side (method of Riva Rocci) ; it is a detail worthy of mention that analogous figures were noted by Claude Bernard in his investigations of the cervical sympathetic nerves.

This vasodilator reaction is only temporary: the hyperthermia, the rise in pressure, and the increase in amplitude of the oscillations diminish little by little; sometimes as early as the 15th day and usually at the end of a month one finds it no more. On the other hand, in some cases in which I have performed sympathectomy on the brachial or the subclavian artery by resecting totally the obliterated arterial cord, the elevations of temperature have been more lasting than in the cases in which a sympathectomy by denudation alone was done. This is comprehensible, for the operation is more complete—the sympathectomy being necessarily total. Classed with these observations should be one made by M. Babinski and M. Heitz: four months after the extirpation of an axillary aneurism the hand on the side operated on was frequently warmer than that on the healthy side. This phenomenon, apparently paradoxical, is understood very well when one considers that the ablation of a sac is in reality a total sympathectomy.

III. The Lessons Furnished by the Operation.—Observation of series of operations and analysis of the therapeutic results permit interesting deductions from physiological and pathological points of view.

1. *From the Physiological Point of View.*—Two facts become clear: The vasomotor phenomena which Heitz and I have studied under the name of vasodilator reaction permit us to isolate the paths along which certain vasoconstrictive acts are conducted and to establish their correct value.

But there is, above all, this one: it seems to follow from certain observations that the voluntary muscular contraction is, in a certain sense, very dependent on the sympathetic nerves. The integrity of the motor nerve and of the muscle are not sufficient to insure the proper accomplishment of the movement that is commanded. If the sympathetic nerve is affected at a distance or if it does not act normally, the muscle becomes hard, and contracts, and the will is powerless to relax or contract it. Now in these cases sympathectomy lifts the barrier and makes possible the progressive reparation of the voluntary movements. In the case of wounded men having reflex

contractions of the Babinski-Froment type, with fingers twisted, motionless, incapable of movement, it has been sufficient to modify the vasomotor innervation to see a certain degree of voluntary motion appear again the following day.

This fact which M. Heitz[6] and I have confirmed several times has a real physiological bearing. What we now know of muscle innervation in man does not lead us to suppose that it is a matter of a directly muscular action. It appears, until we have made further inquiry, that the vasomotor phenomena alone are concerned in it, and a fact which would tend to prove this is that the return of motility coincides with the appearance of the post-operative vasodilator reaction (that is to say, the warming up of the muscle, its new circulatory system), and follows the course of it.

Sympathectomy, furthermore, would appear to establish the fact that the sympathetic nerve is, in man, the excitosecretory nerve of the sweat glands; I have seen profuse sweating of the hand disappear after sympathectomy. The nerve probably also influences the growth of the nails and the trophicity of the skin, since trophic phenomena disappear rapidly after sympathectomy. The nerves of the cerebrospinal system, from this point of view, are probably only the vectors of the sympathetic.

2. *From the Point of View of Pathological Physiology.*—Sympathectomy is, in certain cases, a true method of experimental analysis for the interpretation of certain complex phenomena.

It demonstrates: (a) *The true mechanism of the production of dry wounds of the arteries.* Spontaneous haemostasis, when an artery is divided or destroyed by a projectile, is certainly greatly facilitated by, if it is not entirely due to, the contraction of the artery which follows the destruction of its sympathetic nerve. It may be compared to the considerable diminution of calibre which is observed after sympathectomy. Since a brachial artery is reduced to the size of a radio-palmar or a digital when its sympathetic nerve is excised, it is easy to comprehend how spontaneous haemostasis is possible after certain wounds of the arteries which are inevitably accompanied by tearing of the sheath.

(b) *The real nature of certain causalgias, if not of all.* As I demonstrated to the Société de Neurologie, in January, 1916, one can cure obstinate causalgias by excising the involved sympathetic nerve. This observation proves the sympathetic origin of the violent pains which accompany certain wounds of nerves. In these cases the pain phenomena are not due to the nerve lesions, but to the lesions of the neighboring sympathetic nerve (the perivascular sympathetic of the brachial) or of the intranerve sympathetic (the sympathetic carried to the median, for example, by its particular artery). This explains the fact demonstrated by M. Pierre Marie, M. Miege and Mme. Bénisty that the pain in these nerve wounds is a kind of reaction peculiar to the nerves which have an artery of their own or which are close to a large artery. This fact is now admitted by the neurologists.

(c) *The very great rôle of the sympathetic in the production of the reflex contractions of Babinski-Froment.* Let us pay attention to the character-

[6] Leriche and Heitz: Influence de la sympathectomie péri-artérielle ou de la résection d'un segment artériel oblitéré sur la contraction volontaire des muscles. Société de Biologie, 17 Fevrier, 1917.

istics of this type about which there is so much confusion. I speak now of the true Babinski-Froment type, that in which the vasomotor and thermic phenomena are associated with motor disturbances and with modifications of the mechanical excitability of the muscles.

In the cases of this kind, studied by M. Babinski or by his assistants Froment and Heitz, I have seen with Heitz motor disturbances disappear almost completely after sympathectomy. From the day following the operation, when the vasodilator reaction was very well established, the mobility returned markedly in hands fixed immutably in position, contracted, the fingers being bent into the palms, or else turned back on the dorsal side. I am inclined to believe that a number of these severe cases are referable to disturbances of sympathetic origin, caused by the imprisonment of the nerve ends in a hard and compressing cicatrix.

(d) *The rôle of the sympathetic in the production of certain griffes cubitales.* After brachial sympathectomy I have seen a loosening up of a very rigid *griffe cubitale* which had resisted resection and suture of the nerve divided in the forearm.

I have made this observation only once, but the phenomenon was perfectly definite. It seems to me that the observation should be recorded because of its therapeutic interest.

(e) *The rôle of the sympathetic in the explanation of those motor paralyses, more or less complete, which follow certain arterial lesions.* When the nerves have not been disturbed, we call it ischaemic paralysis, giving to this appellation an entirely different sense from that which we have in mind for the isolated contracture of the flexors of Volkmann. In the cases described by MM. Déjerine and Tinel there is rather complete motor paralysis with the reaction of degeneration, yet the nerves were not divided. The paralysis coincides with an oedematous infiltration of the hand with marked vasomotor disturbances which lead to true fibrous transformation of the hand. At the end of some weeks the oedema begins to diminish, the tendons and the aponeuroses are ensheathed in a veritable fibrous envelope; the muscles, already hard and tense, retract and take on a ligneous consistency. In this picture is seen the mark of the sympathetic; and in doing sympathectomy in these cases M. Heitz and I have seen vasomotor disturbances disappear, trophic disturbances improve, the tendons and the muscles become on palpation sensibly more supple, and the muscles execute slight movements. In one case, although before operation there had been complete degenerative reaction, four months after operation we observed a very definite amelioration of the electric reactions, and we are hoping for a marked functional recuperation.

I do not wish to say that sympathectomy cures the patients; and it is impossible that it should cure them at once when one considers their wounds. Unhappily, there is no cure, but to me it appears to have caused the disappearance (at least momentarily) of the stiffness of the muscles and tendons; it has assured a manifest suppling up of muscles which, after the sympathectomy, executed movements equivalent to one half the normal. Referring to the fact mentioned above à propos of *griffe cubitale,* I have the impression that the sympathetic has an enormous influence on the evolution and production of fibrous tissue. The sclerous evolution is modified, it appears, when a vasodilator reaction is brought about. Whence the conclusion

that the sympathetic plays probably a large rôle in the mechanism of the so-called ischaemic paralyses where the predominating feature has not the mark of ischaemia. I do not mean to say that the circulatory suppression caused by the arterial lesion does not play any part, that would be absurd; what I would say is that something more is involved. But these cases are too rare in general surgical practice for me to follow the analysis alone.

(f) *The rôle of the sympathetic in the production of heel sloughs in the course of medullary lesions.* In one patient who had had flabby incomplete paralysis of the lower limbs with absence of reflexes, and incontinence of urine, there were two sloughs, one on the heel, the other on the little toe. They resisted all treatment. Three months after the wound had been received, a femoral sympathectomy was done. Three days later the ulceration of the toe was dry and cicatrized; that of the heel, which was as large as a small palm of the hand, diminished in size and was covered with active granulations. In thirty-five days it was completely cicatrized.

3. *From the Therapeutic Point of View.*—I have tried sympathectomy in a great variety of cases, and it is rather difficult for me to analyse the results, because there were often complex situations to be dealt with. Schematically, I have tried to influence the element of pain, the element of reflex contraction with vasomotor disturbances, and the trophic element. In all the cases I have had failures and disappointments.

I have done sympathectomy eleven times for phenomena of pain; once the vasodilator reaction failed. This operation was badly done and I eliminate it. For the ten others, six times there were true causalgias, and three times phenomena of pain more or less intense.

For *causalgia* I operated four times on the upper extremity, twice on the lower limb. The four cases in the upper extremity resulted as follows: One complete failure (patient operated on in the service of M. Gosset), two excellent results (complete suppression of the pains, total transformation of the patients) with final cure, now dating back 19 and 16 months. These two patients have been discharged, and are earning their living exclusively by their own work.

In a fourth case, which was very serious, I had found the brachial artery obliterated. I had not at the time thought that there would be any advantage in resecting the obliterated segment. I performed then a sympathectomy by denudation. The patient was much improved; he who for months had been confined to his bed with a wet cloth on his hand, apprehensive, indifferent to everything except his pain, got up and submitted to the same régime as his comrades; but some pains persisted. In order to improve these I again took the patient under my care and resected the obliterated arterial segment, whereupon the persisting disturbances almost completely vanished; this result promises to be permanent.[7]

In the lower limb I did one femoral sympathectomy, with appreciable amelioration. At a second operation I resected the sciatic artery and the artery of the sciatic nerve, with manifest result, but the cure has not been complete. The patient, who has been followed for six months, is entirely

[7] In one of the last Bulletins of the Société de Chirurgie a very interesting observation by M. Le Jemtel is reported, which shows well the rôle of the sympathetic in the paretic syndrome following an obliteration of the brachial.

relieved at certain times, but has suffered much at others in damp weather. His general condition is transformed. For those who know the lamentable condition of degeneration of these patients caused by their martyrdom of pain, the words " great amelioration " have a real significance. This expression should not be taken as a euphemism masking a failure.

In another case I did a common iliac sympathectomy, which resulted in great improvement [grande amélioration] with complete transformation of the general condition. The patient has suffered at certain times, but his days of respite have been greater in number than his days of pain. This is also, to my thinking, a success worth trying for.

For all " causalgiques " the question is complex in other ways: these patients have a psychology of their own; it is necessary to isolate them somewhat and to exercise over them a little authority if we desire to cure them. Besides, they are extremely sensitive to atmospheric changes, and it seems as if their whole vasomotor system were out of equilibrium. One local operation could not pretend to set all this right at once, and these patients should not be regarded exactly as others.

I have operated *four times for phenomena of pain accompanying nerve lesions* or arterial obliterations. I had three excellent results and one complete failure.

To sum up, in the treatment of the phenomena of pain, sympathectomy cures entirely certain patients, acts very favorably in the majority of cases, but does not succeed always or always give an absolutely perfect result.

Five sympathectomies for *trophic ulcerations,* with or without phlyctenae in the neighborhood, gave success five times.

I have operated three times for large *bluish oedemas* of the limbs, with one complete success; one great improvement, followed at the end of several months by complete cure; one incomplete result with partial return (in the lower limb), but on the whole, amelioration.

For reflex disturbances, eighteen sympathectomies among the patients examined heretofore (except two) either by M. Babinski, or by his assistants M. Froment and M. Heitz, and all followed up by M. Heitz, have resulted as follows:[8]

Three cures, practically complete, traced for several months, with disappearance of the vasomotor disturbances and of the contraction;

Ten ameliorations more or less considerable, some of which were almost cures;

Two ameliorations followed by incomplete return in patients who had not received any postoperative treatment. In the two cases the lasting benefit has been real;

One case in which the operation, after failure of all other treatments, has been followed by the execution of voluntary movements; also, thanks to treatment followed regularly under the direction of M. Heitz, motility is returning little by little;

Two complete failures. In these two patients there had been after operation a beginning return of voluntary motility, but the therapeutic result has been practically nil.

[8] The observations will be published *in extenso* in the August number of *Lyon chirurgical,* under the following title: Résultats de la sympathectomie péri-artérielle dans le traitement des troubles nerveux post-traumatiques d' ordre réflexe.

In all the patients who have been really benefited by the operation (16) the vasodilator reaction has been followed by a diminution of the contraction and by a reappearance more or less complete of the voluntary movements. In some cases the result has been surprising: from the day following operation the patients were able to make movements which had been impossible for months. But at the end of two or three weeks, as the vasodilator reaction subsided, the contraction shows signs of beginning anew and the movements diminish in amplitude. Observing this, we thought, with M. Heitz, that the maintenance of heat in the member operated upon was indicated. For this purpose M. Heitz has made my patients take baths of paraffine at 60° for about one half hour. By associating with this treatment massage and reeducation Heitz has obtained very interesting results, which permit us to speak, in certain cases, of true cure.

Briefly, then, *in the grave forms of the syndrome of Babinski-Froment* sympathectomy by itself does not suffice. But without it, the treatment usually applied soon ceases to influence the condition, and the result becomes stabilized; the operation, like so many other operations upon the nervous system, leaves room for and facilitates reeducation, and gives to it its efficacy. It is only one phase of the treatment, but it is a very rewarding phase. I insist on this point so that we shall not expose ourselves to failures all the more bitter when the operation at the outset promised to yield a brilliant result. And I recall what Heitz has recently written:[9] it is the mixed method (operation on the sympathetic followed by the treatment indicated above) which has given in the service of M. Babinski the best results.

For the paralyses connected with vascular obliterations, associated or not with nerve lesions, sympathectomies have improved the condition without giving, except in one case, a true functional result. In such case the sympathectomy should be done to modify the vascularization of the paralyzed segment, to check the fibrous regression of the muscles. It cannot constitute of itself a sufficient treatment, but it has appeared to me to be interesting and useful. The future will determine its indication.

It is the same in regard to the value of sympathectomy associated with operations upon the nerves in cases of rebellious contracture of the median or of the ulnar nerve variety. One cannot say definitely, but the question appears to me to merit consideration.[10]

In order to estimate the results of sympathectomy, I have striven to be as concrete as possible: I have appraised as nil any result which was without value for the patient. The verdict may perhaps appear to be very reserved. Truly, I believe that the operation is a very interesting one and a useful expedient to which one may resort in cases, very diverse, which have been irresponsive to all other treatments; but it remains for us to define clearly the indications for it.

[9] Heitz: Des troubles circulatoires qui accompagnent les paralysies ou les contractures post-traumatiques d'ordre reflexe. Archives des maladies du coeur, Avril, 1917, p. 160.

[10] Recently I tried to arrest, by sympathectomy, the appearance of gangrene after resection of the popliteal vessels. The operation was followed by complete disappearance of the pains; it changed the hue of the violet-colored spots which covered the limb. For 36 hours I hoped for a therapeutic result, but none appeared, and I had to amputate the thigh.

THE EFFECT ON THE WALLS OF BLOOD VESSELS OF PARTIALLY AND COMPLETELY OCCLUDING BANDS[1]

It was very gratifying to me to receive about a year ago a letter from Dr. Vaughan announcing that he had successfully placed in the human subject a partially occluding band of tape about the aorta.

Those are in error who have stated that there is no necrosis of the aortic wall under the partially occluding ligature or band. The included portion of the wall always dies whether the occlusion is partial or complete. The danger of haemorrhage is greater from partial than from complete occlusion, for in the former case the only protection from haemorrhage is a new connective tissue capsule which after a time embraces the band. When, however, the occlusion is complete the necrosed wall may become converted into a cylindrical fibrous cord, the absorption and substitution taking place by means of capillaries which penetrate the dead wall under the band both from above and from below. I am quite sure, as I have repeatedly stated, that notwithstanding much testimony to the contrary union between intimal surfaces of a large artery maintained in contact under ligatures or bands cannot take place, for the compressed portion of the wall of the artery always becomes necrotic.

A few years ago Dr. Reid and I placed partially occluding bands about the pulmonary artery and were interested to note how slowly relatively bands about this artery cut through it. In one dog sacrificed about 1½ years after the operation we found that the metal band had cut through only along a line 2 or 3 mm. long at its upper edge and that the protecting capsule was firmest just over this linear defect in the wall of the pulmonary artery. We assumed that the delay in the cutting through and absorption of this portion of the wall of the artery was due to the fact that the pressure from within was much less than in the aorta, and this being so, the force required to occlude the pulmonary artery is less than that necessary to coarct the aorta to the same degree. With this idea in mind, I tested on dogs about eighteen months ago the effect on the wall of the vena cava of partially and totally occluding metal bands, and found after periods of six or less months

[1] Brief remarks in discussion of Dr. George Tully Vaughan's paper, "Notes on a case of ligation of the aorta two years and one month after operation." American Surgical Association, Washington, D. C., May 2, 1922.

Tr. Am. Surg. Ass., Phila., 1922, xl, 201-202.

that the compressed venous wall was intact and thickened. Hence the greater the force required to occlude the vessel, namely, the greater the vascular pressure, the more rapid will be the absorption of the necrotic wall. When the pressure from within is nil or so nearly nil as it is in the veins the band does not cut through.

It will be interesting to determine by further experimentation and microscopic study of the specimens the processes by which the infoldings of the venous wall under the band eventually disappear—how the wall of the coarcted portion of the vein loses its wrinkles and becomes thickened.